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NODIA EDITIONS LLP
125, Sector 6, Vidyadhar Nagar, Jaipur 302039
Phone :+91 9001005245
email : mail@nodia.in

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CHAPTER 01
Chemical Reactions and Catalysts

1. Which of the following processes represents a physical change in matter?
(A) Sublimation of iodine
(B) Digestion of food
(C) Rusting of iron
(D) Burning of magnesium ribbon

2. What happens to the chemical composition of a substance during a chemical change?
(A) It remains entirely unchanged in state and structure
(B) It undergoes alterations in physical state only
(C) It changes to form a completely new substance
(D) It suffers permanent loss of its overall mass

3. Which of the following is a key difference between physical and chemical changes?
(A) Physical changes are generally reversible, while chemical changes are irreversible
(B) Physical changes are mostly irreversible in nature, while chemical changes are easily reversible
(C) Physical changes involve the constant formation of new substances, while chemical changes do not
(D) Physical changes always absorb net heat energy, while chemical changes always release heat

4. The souring of milk when left at room temperature during summer is an example of which type of change?
(A) Reversible physical change
(B) Irreversible physical change
(C) Radioactive change
(D) Chemical change

5. Which of the following represents the correct order of steps for writing a balanced chemical equation?
(A) Write physical states, write skeletal equation, balance atoms of each element
(B) Write skeletal equation, balance atoms of each element, write physical states
(C) Balance atoms of each element, write skeletal equation, write physical states
(D) Write skeletal equation, write physical states, balance atoms of each element

6. During a chemical reaction, which of the following characteristics is not typically observed?
(A) Change in colour
(B) Evolution of a gas
(C) Creation of new atoms
(D) Change in temperature

7. The reaction between lead nitrate and potassium iodide solutions is characterised by which of the following visual changes?
(A) Evolution of thick brown fumes throughout
(B) Formation of a dense white precipitate
(C) Rapid decrease in overall reaction temperature
(D) Formation of a yellow precipitate

8. In a chemical equation, what does the symbol (aq) written after a reactant or product indicate?
(A) Substance dissolved in water
(B) The chemical substance is in liquid state
(C) The chemical substance is in gaseous state
(D) The substance is chemically highly reactive

9. Why must a chemical equation always be balanced?
(A) To satisfy the Law of Constant Proportions
(B) To satisfy the Law of Conservation of Mass
(C) To satisfy the Law of Multiple Proportions
(D) To ensure equal volumes of gases are produced

10. Consider the following statements regarding physical and chemical changes:
I. Melting of wax is a physical change, whereas burning of wax is a chemical change.
II. A chemical change always results in the formation of one or more new substances.
III. Dissolving sugar in water is an example of a chemical change.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only

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(C) II and III only
(D) I, II and III

11. Which of the following reactions is a classic example of a combination reaction?
(A) Calcium oxide reacting with water
(B) Calcium carbonate decomposing into calcium oxide and carbon dioxide
(C) Iron metal reacting with aqueous copper sulphate solution
(D) Zinc metal reacting with dilute sulphuric acid solution

12. What type of reaction occurs when a single reactant breaks down to give simpler products?
(A) Combination reaction
(B) Displacement reaction
(C) Decomposition reaction
(D) Double displacement reaction

13. The heating of ferrous sulphate crystals results in the evolution of a gas with the characteristic odour of burning sulphur. This is an example of which reaction?
(A) Photolytic decomposition
(B) Electrolytic decomposition
(C) Displacement
(D) Thermal decomposition

14. Which of the following gases is evolved when zinc granules are treated with dilute sulphuric acid?
(A) Oxygen
(B) Nitrogen
(C) Hydrogen
(D) Carbon dioxide

15. Match List I with List II:
List I: (Type of chemical reaction)
P. Combination
Q. Decomposition
R. Displacement
S. Double displacement
List II: (Chemical Equation)
1. $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
2. $Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2NaCl$
3. $C + O_2 \rightarrow CO_2$
4. $2H_2O \rightarrow 2H_2 + O_2$
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

16. In the reaction $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$, why does iron displace copper?
(A) Iron is less reactive than copper
(B) Copper is a non-metal
(C) Both are equally reactive
(D) Iron is more reactive than copper

17. Which of the following defines a double displacement reaction?
(A) Exchange of ions between reactants
(B) Two or more simple elements combine to form a single complex compound
(C) A more reactive element displaces a less reactive element from its compound
(D) A complex chemical compound breaks down into two or more simpler elements

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18. When silver chloride is exposed to sunlight, it turns grey. Which type of reaction is this?
(A) Thermal decomposition reaction
(B) Electrolytic decomposition reaction
(C) Photolytic decomposition
(D) Double displacement reaction

19. What is the fundamental definition of oxidation in terms of classical chemistry?
(A) Addition of oxygen or removal of hydrogen
(B) Addition of hydrogen or removal of oxygen
(C) Gain of electrons
(D) Decrease in oxidation state

20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In the reaction $CuO + H_2 \rightarrow Cu + H_2O$, copper oxide is reduced and hydrogen is oxidised.
Reason (R): Reduction is the loss of oxygen and oxidation is the gain of oxygen.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

21. Which term is used to describe a substance that gives oxygen for oxidation or removes hydrogen?
(A) Reducing substance
(B) Oxidising agent
(C) Chemical catalyst
(D) Chemical indicator

22. In the electronic concept of redox reactions, what does reduction represent?
(A) Loss of electrons
(B) Sharing of electrons
(C) Gain of electrons

(D) Loss of protons

23. Identify the reducing agent in the following reaction: $H_2S + Cl_2 \rightarrow 2HCl + S$
(A) Cl_2
(B) HCl
(C) S
(D) H_2S

24. What is the process of slow eating away of a metal due to the attack of atmospheric gases and moisture called?
(A) Corrosion
(B) Rancidity
(C) Reduction
(D) Galvanisation

25. Match List I with List II:
List I: (Metal)
P. Iron
Q. Copper
R. Silver
S. Aluminium
List II: (Colour of Corrosion Product)
1. Black
2. Green
3. Reddish-brown
4. Dull white
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-2, R-4, S-3

26. What is the chemical formula of rust?
(A) FeO
(B) $Fe_2O_3.xH_2O$
(C) Fe_2O_3
(D) Fe_3O_4

27. Which process involves coating iron articles with a thin layer of zinc to prevent rusting?
(A) Galvanisation
(B) Tinning
(C) Electroplating
(D) Anodising

28. What term describes the oxidation of fats and oils in food resulting in a bad smell and taste?
(A) Corrosion
(B) Fermentation
(C) Rancidity
(D) Hydrogenation

29. Which gas is typically flushed into bags of potato chips by manufacturers to prevent them from getting oxidised?
(A) Oxygen
(B) Hydrogen
(C) Chlorine
(D) Nitrogen

30. Consider the following statements regarding oxidation and reduction:
I. Oxidation involves an increase in the oxidation number of an element.
II. A reducing agent undergoes reduction during a chemical reaction.
III. Oxidation and reduction always occur simultaneously in a redox reaction.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

31. What is a substance that alters the rate of a chemical reaction without itself undergoing any permanent chemical change?
(A) Reactant
(B) Catalyst
(C) Inhibitor
(D) Substrate

32. How does a positive catalyst increase the rate of a chemical reaction?
(A) By significantly increasing the overall temperature of the reaction mixture
(B) By substantially increasing the overall activation energy barrier
(C) By increasing the total mass and surface area of all reactants
(D) By providing a lower activation energy pathway

33. Which of the following acts as a negative catalyst by decreasing the decomposition rate of hydrogen peroxide?
(A) Glycerol
(B) Manganese dioxide
(C) Finely divided iron
(D) Platinum sponge

34. What are enzymes chemically?
(A) Complex polymeric carbohydrates
(B) High molecular weight lipids
(C) Nitrogenous proteins
(D) Simple inorganic mineral salts

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35. Match List I with List II:
List I: (Catalyst)
P. Finely divided Iron
Q. Platinised Asbestos / Vanadium pentoxide
R. Nickel
S. Platinum gauze
List II: (Industrial Process)
1. Contact process for Sulphuric acid
2. Haber process for Ammonia
3. Ostwald process for Nitric acid
4. Hydrogenation of vegetable oils
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

36. Which term is used for a substance that is not a catalyst itself but increases the efficiency of a catalyst?
(A) Chemical catalyst poison
(B) Reaction auto-catalyst
(C) Chemical reaction inhibitor
(D) Catalyst promoter

37. In the Haber process for the manufacture of ammonia, which substance is commonly used as a catalyst promoter for iron?
(A) Nickel
(B) Molybdenum
(C) Platinum
(D) Copper

38. What is homogeneous catalysis?
(A) The catalyst and reactants exist in entirely different physical states
(B) The chemical reaction produces only a single uniform and homogeneous product
(C) The catalyst and reactants are in the same phase
(D) The chemical reaction is catalysed exclusively by absorbed light energy

39. The hydrogenation of vegetable oil using solid nickel as a catalyst is an example of which type of catalysis?
(A) Homogeneous chemical catalysis
(B) Reaction auto-catalysis
(C) Biological enzyme catalysis
(D) Heterogeneous catalysis

40. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Enzymes are highly specific in their catalytic action.
Reason (R): A particular enzyme can catalyse only one specific reaction due to the unique shape of its active site.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

41. Which of the following is an example of auto-catalysis?
(A) Thermal decomposition of potassium chlorate in the presence of manganese dioxide catalyst
(B) Oxidation of oxalic acid by potassium permanganate
(C) Industrial synthesis of ammonia gas from nitrogen and hydrogen using iron catalyst
(D) Catalytic oxidation of sulphur dioxide into sulphur trioxide using nitric oxide

42. What is the phenomenon called when a chemical reaction, which normally does not take place, is forced to proceed by the occurrence of another chemical reaction?
(A) Auto-catalysis
(B) Induced catalysis
(C) Bio-catalysis
(D) Heterogeneous catalysis

43. Which enzyme converts glucose and fructose into ethanol and carbon dioxide?
(A) Zymase
(B) Invertase
(C) Diastase
(D) Maltase

44. Zeolites are good shape-selective catalysts because of their specific:
(A) Exceptionally high chemical density
(B) High solubility in aqueous water solvent
(C) Honeycomb pore structure
(D) Prominent metallic surface lustre

45. Match List I with List II:
List I: (Enzyme)
P. Invertase
Q. Urease
R. Pepsin
S. Amylase
List II: (Conversion Process)
1. Urea into ammonia and carbon dioxide

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2. Proteins into peptides
3. Cane sugar into glucose and fructose
4. Starch into maltose

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

46. A chemical reaction in which heat is liberated is known as:
(A) Endothermic reaction
(B) Photochemical reaction
(C) Exothermic reaction
(D) Electrochemical reaction

47. Respiration in living beings is considered which type of chemical reaction?
(A) Endothermic
(B) Exothermic
(C) Displacement
(D) Double displacement

48. A chemical reaction in which heat is absorbed is called:
(A) Exothermic chemical reaction
(B) Rapid combustion reaction
(C) Acid-base neutralisation
(D) Endothermic reaction

49. Which of the following is an example of an endothermic process?
(A) Photosynthesis in plants
(B) Burning of natural gas
(C) Dilution of a strong acid
(D) Respiration

50. Consider the following statements regarding catalysts:
I. A catalyst changes the equilibrium constant of a reversible reaction.
II. A catalyst does not initiate a reaction; it only changes its speed.
III. Enzymes are biocatalysts that function best at an optimum temperature.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

51. What is the process of burning a substance in the presence of oxygen to produce heat and light called?
(A) Combustion
(B) Reduction
(C) Fermentation
(D) Sublimation

52. Which highly poisonous gas is formed during the incomplete combustion of carbon-based fuels?
(A) Carbon dioxide
(B) Sulphur dioxide
(C) Nitrogen dioxide
(D) Carbon monoxide

53. The reaction between an acid and a base to give a salt and water is known as:
(A) Esterification
(B) Neutralisation
(C) Saponification
(D) Crystallisation

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54. When a strong acid reacts with a strong base, the resulting salt solution will be:
(A) Highly acidic
(B) Highly basic
(C) Neutral
(D) Amphoteric

55. Match List I with List II:
List I: (Process)
P. Burning of coal
Q. Dissolving ammonium chloride in water
R. Mixing sodium hydroxide and hydrochloric acid
S. Decomposition of calcium carbonate
List II: (Type of Heat Change)
1. Endothermic
2. Exothermic
3. Exothermic
4. Endothermic

(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

56. Any reaction that produces an insoluble solid that separates from the solution is called a:
(A) Precipitation reaction
(B) Neutralisation reaction
(C) Redox reaction
(D) Addition reaction

57. Which color of precipitate is formed when aqueous sodium sulphate reacts with aqueous barium chloride?
(A) Yellow
(B) White
(C) Black
(D) Green

58. The process of digestion of food in our body is primarily an example of which type of chemical reaction?
(A) Combination
(B) Decomposition
(C) Displacement
(D) Isomerisation

59. The decomposition of organic waste into compost is an example of an:
(A) Exothermic reaction
(B) Endothermic reaction
(C) Electrolytic reaction
(D) Reversible physical change

60. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Adding water to concentrated sulphuric acid is a highly exothermic process.
Reason (R): Dilution of strong acids involves the absorption of a large amount of heat energy from the surroundings.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

61. Which factor generally increases the rate of a chemical reaction?
(A) Significantly decreasing the reaction temperature
(B) Decreasing the overall concentration of reactants
(C) Completely removing the chemical catalyst
(D) Increasing reactant surface area

62. Why does powdering a solid reactant increase the rate of reaction?
(A) It significantly decreases the required activation energy
(B) It substantially increases the temperature of the solid material
(C) It exposes a larger surface area
(D) It fundamentally changes the chemical nature of the solid

63. According to collision theory, an increase in temperature increases the reaction rate mainly because:
(A) It significantly decreases the total number of molecular collisions occurring per second
(B) More molecules gain energy exceeding activation energy
(C) It substantially increases the overall activation energy barrier required for reaction
(D) It forces the entire chemical process to become highly endothermic in nature

64. What is the term for the minimum extra amount of energy absorbed by reactant molecules so that their energy becomes equal to threshold value?
(A) Molecular kinetic energy
(B) Chemical potential energy
(C) Internal thermal energy
(D) Activation energy

65. Match List I with List II:
List I: (Term)
P. Oxidation
Q. Reduction
R. Oxidising Agent
S. Reducing Agent
List II: (Definition)
1. Gains electrons during a reaction
2. Loses electrons during a reaction
3. Process involving loss of electrons
4. Process involving gain of electrons
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

66. Which acid is commonly present in gastric juice and helps in the digestion of food?
(A) Concentrated sulphuric acid
(B) Dilute nitric acid
(C) Hydrochloric acid
(D) Organic acetic acid

67. According to the Arrhenius concept, an acid is a substance that:
(A) Gives hydrogen ions (H^+) in aqueous solution
(B) Accepts a proton in aqueous solution
(C) Gives hydroxide ions (OH^-) in aqueous solution
(D) Donates an electron pair

68. According to the Arrhenius concept, a base is a substance that:
(A) Generates free hydrogen ions (H^+) when dissolved in water
(B) Readily accepts a lone electron pair from another species
(C) Changes the colour of blue litmus paper to

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bright red
(D) Produces OH- ions in water

69. What is the color change observed when blue litmus paper is dipped in an acidic solution?
(A) Blue to Green
(B) Blue to Red
(C) Blue remains Blue
(D) Blue to Yellow

70. Consider the following statements regarding the pH scale:
I. The pH scale measures the hydrogen ion concentration in a solution.
II. A solution with a pH of 7 is considered neutral.
III. Higher the hydronium ion concentration, higher is the pH value.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

71. The 'p' in pH stands for 'potenz', which is a German word meaning:
(A) Potential difference
(B) Proton
(C) Positive
(D) Power

72. What is the typical pH range of the human body for normal physiological functioning?
(A) 5.0 to 5.8
(B) 7.0 to 7.8
(C) 8.0 to 9.0
(D) 6.0 to 6.5

73. Rain is conventionally called acid rain when its pH falls below:
(A) 7.0
(B) 6.5
(C) 5.6
(D) 4.0

74. Tooth decay usually starts when the pH of the mouth is lower than:
(A) 7.0
(B) 6.5
(C) 5.5
(D) 8.0

75. Match List I with List II:
List I: (Everyday substance)
P. Pure water
Q. Lemon juice
R. Blood
S. Milk of Magnesia
List II: (Approximate pH Nature)
1. Highly acidic (pH ~2)
2. Neutral (pH = 7)
3. Mildly basic (pH ~7.4)
4. Basic (pH ~10)
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-4, S-2

76. Which type of chemical compounds are commonly used as antacids to neutralize excess acid in the stomach?
(A) Strong acids
(B) Strong bases
(C) Mild bases
(D) Neutral salts

77. Which acid is injected into the skin by the sting of a honey bee?
(A) Concentrated acetic acid (ethanoic acid)
(B) Naturally occurring citric acid
(C) Organic tartaric acid
(D) Methanoic acid

78. A traditional remedy for a nettle sting is rubbing the affected area with the leaf of a dock plant. This implies that the dock plant leaf is naturally:
(A) Acidic
(B) Neutral
(C) Basic
(D) Highly corrosive

79. What is the chemical name of baking soda?
(A) Anhydrous sodium carbonate compound
(B) Sodium hydrogen carbonate
(C) Crystalline sodium chloride salt
(D) Solid caustic sodium hydroxide

80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Plaster of Paris is stored in a moisture-proof container.
Reason (R): Plaster of Paris reacts with moisture to form a hard solid mass called gypsum.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.

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(D) Assertion (A) is false but Reason (R) is true.

81. Which process is used for the industrial preparation of sodium hydroxide from aqueous sodium chloride?
(A) Chlor-alkali process
(B) Industrial Haber process
(C) Catalytic Ostwald process
(D) Industrial Contact process

82. Which gas is liberated at the anode during the electrolysis of brine (aqueous NaCl)?
(A) Hydrogen
(B) Oxygen
(C) Chlorine
(D) Nitrogen

83. Bleaching powder is produced by the action of chlorine on which substance?
(A) Dry calcium hydroxide
(B) Calcium oxide commonly known as quicklime
(C) Naturally occurring calcium carbonate limestone
(D) Hydrated calcium sulphate mineral known as gypsum

84. What is the chemical formula of washing soda?
(A) $NaHCO_3$
(B) Na_2CO_3
(C) NaOH
(D) $Na_2CO_3.10H_2O$

85. Match List I with List II:
List I: (Common Name)
P. Bleaching powder
Q. Baking soda
R. Washing soda
S. Plaster of Paris
List II: (Chemical Formula)
1. $Na_2CO_3.10H_2O$
2. $CaOCl_2$
3. $CaSO_4.1/2H_2O$
4. $NaHCO_3$
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-3, R-2, S-1

86. How many molecules of water of crystallisation are present in one formula unit of copper sulphate crystals?
(A) 2
(B) 5
(C) 7
(D) 10

87. Heating gypsum at 373 K (100°C) results in the formation of:
(A) Quicklime
(B) Slaked lime
(C) Bleaching powder
(D) Plaster of Paris

88. What is the primary constituent of antacids like 'Milk of Magnesia'?
(A) Magnesium hydroxide
(B) Hydrated calcium hydroxide
(C) Caustic sodium hydroxide
(D) Crystalline aluminium chloride

89. Which of the following is a naturally occurring indicator?
(A) Methyl orange
(B) Turmeric
(C) Phenolphthalein
(D) Universal indicator

90. Consider the following statements regarding strong and weak acids:
I. Hydrochloric acid is a strong acid because it completely ionises in water.
II. Acetic acid is a weak acid because it partially ionises in water.
III. Strong acids possess high pH values compared to weak acids at the same concentration.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

91. In a neutralisation reaction between a strong acid and a weak base, the nature of the resulting salt is:
(A) Acidic
(B) Neutral
(C) Basic
(D) Amphoteric

92. Which element acts as an important catalyst in the catalytic converters of modern automobiles to reduce toxic emissions?
(A) Finely divided iron metal
(B) Finely powdered nickel catalyst
(C) Platinum-Rhodium
(D) Granulated copper metal

93. A student notes the sour taste of a lemon. This sourness is chemically due to the presence of:
(A) Bases
(B) Salts

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(C) Sugars
(D) Acids

94. Phenolphthalein indicator in a basic (alkaline) solution shows which colour?
(A) Colourless
(B) Yellow
(C) Pink
(D) Red

95. Which of the following options represents the correct sequence of increasing reactivity of metals?
(A) Potassium, Magnesium, Zinc, Iron
(B) Iron, Zinc, Magnesium, Potassium
(C) Zinc, Iron, Potassium, Magnesium
(D) Iron, Potassium, Zinc, Magnesium

96. What is the standard term for reactions that proceed in both forward and backward directions?
(A) Irreversible reactions
(B) Combination reactions
(C) Photochemical reactions
(D) Reversible reactions

97. In a reversible chemical reaction at equilibrium, the effect of a catalyst is to:
(A) Accelerate both forward and backward reactions equally
(B) Substantially increase the overall net equilibrium yield of the products
(C) Selectively increase the rate of the forward reaction only without affecting the reverse
(D) Significantly decrease the rate of the backward reaction to favor products

98. When a copper vessel is exposed to moist air for a long time, it acquires a dull green coating. This green material is a mixture of:
(A) Mixture of copper oxide and copper sulphate
(B) Combination of copper chloride and copper oxide
(C) Basic copper carbonate
(D) Combination of copper nitrate and copper carbonate

99. Which of the following reactions best demonstrates an everyday application of a chemical catalyst?
(A) Adding yeast to dough
(B) Completely dissolving sugar crystals in hot tea
(C) Slowly melting solid butter on hot toast
(D) Finely crushing a medicinal tablet to swallow it easily

100. Which type of enzyme is responsible for the breakdown of starch in the human mouth?
(A) Gastric pepsin
(B) Pancreatic lipase
(C) Pancreatic trypsin
(D) Salivary amylase

101. The addition of non-metallic element to a substance is defined as:
(A) Reduction
(B) Oxidation
(C) Neutralisation
(D) Precipitation

102. An increase in the concentration of reactants typically increases the rate of reaction. Which theory best explains this observation?
(A) Kinetic theory of gases
(B) Bohr's theory
(C) Collision theory
(D) Quantum theory

103. Which is the most appropriate method to prevent the rusting of an iron bridge?
(A) Wrapping it in plastic
(B) Keeping it submerged in pure water
(C) Passing an electric current through it constantly
(D) Applying a coating of paint

104. Which of the following changes cannot be reversed easily?
(A) Baking of a cake
(B) Melting of ice
(C) Boiling of water
(D) Dissolving salt in water

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105. Identify the incorrect statement regarding chemical reactions:
(A) Mass is conserved during a chemical reaction
(B) Physical state of substances never changes in a chemical reaction
(C) The atoms of one element do not change into those of another element
(D) Total number of atoms remains the same before and after the reaction

106. In the chemical formula $2H_2O$, the number '2' written before H_2O is known as the:
(A) Chemical subscript number
(B) Stoichiometric coefficient
(C) Fundamental atomic number
(D) Overall molecular oxidation state

107. Which chemical compound is typically used in black and white photography?
(A) Silver bromide
(B) Silver chloride
(C) Silver nitrate
(D) Sodium chloride

108. Why is respiration considered an exothermic reaction?
(A) It requires sunlight to occur
(B) It absorbs heat from the body
(C) It releases energy in the form of ATP and heat
(D) It takes place only in the presence of a catalyst

109. Which of the following is a physical change rather than a chemical change?
(A) Natural souring of fresh milk
(B) Microbial fermentation of grape juice
(C) Complete burning of dry wood
(D) Crystallisation of salt

110. An aqueous solution turns red litmus solution blue. Excess addition of which of the following solutions would reverse the change?
(A) Baking powder
(B) Lime water
(C) Hydrochloric acid
(D) Ammonium hydroxide solution

111. Which acid is abundantly found in tomatoes?
(A) Acetic acid
(B) Oxalic acid
(C) Citric acid
(D) Tartaric acid

112. The soil in a farmer's field is highly acidic and plant growth is poor. Which substance should be added to the soil to neutralise it?
(A) Common salt (Sodium chloride)
(B) Vinegar (Acetic acid)
(C) Sugar
(D) Quicklime (Calcium oxide)

113. What is the pH of a 0.1 M HCl solution approximately?
(A) 1
(B) 7
(C) 13
(D) 14

114. Which salt is formed when potassium hydroxide reacts with nitric acid?
(A) Potassium sulphate
(B) Potassium chloride
(C) Potassium nitrate
(D) Sodium nitrate

115. Arrange the following aqueous solutions in the correct sequence of increasing pH values:
I. Milk of magnesia
II. Gastric juice
III. Human blood
IV. Pure water
(A) II, IV, III, I
(B) I, III, IV, II
(C) II, III, IV, I
(D) IV, III, II, I

116. A basic salt is formed by the neutralisation of:
(A) Strong acid and strong base
(B) Weak acid and weak base
(C) Strong acid and weak base
(D) Weak acid and strong base

117. What is the chemical name of the acid present in curd?
(A) Citric acid
(B) Lactic acid
(C) Formic acid
(D) Tartaric acid

118. Which of the following statements best describes the principle of food preservation using antioxidants?
(A) They act as positive catalysts that significantly speed up food degradation
(B) They effectively neutralise all organic acids naturally present in food
(C) They act as reducing agents preventing oxidation
(D) They add controlled moisture to preserve and keep the food soft and fresh

119. What is the main purpose of adding a few drops of dilute sulphuric acid to pure water before electrolysis?
(A) To significantly increase the overall boiling point of pure water
(B) To function as a negative chemical catalyst during the electrolysis
(C) To completely neutralise any basic alkaline species present in water
(D) To increase the electrical conductivity of water

120. Arrange the following steps involved in the process of galvanisation in the correct operational sequence:

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I. Dipping the iron article into a bath of molten zinc.
II. Cleaning the surface of the iron article to remove rust and impurities.
III. Cooling the article to allow the zinc layer to solidify.
IV. Formation of a protective layer of zinc on the iron surface.

(A) II, I, IV, III
(B) I, II, III, IV
(C) II, IV, I, III
(D) I, III, II, IV

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ANSWERS

1. (A) Sublimation of iodine
Sublimation of iodine involves the direct phase transition of solid iodine into vapor without altering its underlying chemical composition. Because no new chemical substances with distinct molecular properties are formed, the process represents a physical change. Reversible physical changes preserve original molecular structures despite alterations in physical state, appearance, or volume.

2. (C) It changes to form a completely new substance
During a chemical change, atomic bonds in the reacting molecules break and rearrange to form entirely new chemical substances with distinct chemical and physical properties. The original chemical composition undergoes fundamental transformation, yielding products that possess different chemical identities compared to starting materials. Such reactions are generally irreversible under standard environmental conditions.

3. (A) Physical changes are generally reversible, while chemical changes are irreversible
Physical changes alter only physical properties like shape, size, or state without forming new substances, making them generally reversible by simple physical methods. Conversely, chemical changes involve breaking and forming chemical bonds to produce entirely new substances with different compositions, rendering them permanent and practically irreversible under standard environmental conditions.

4. (D) Chemical change
Souring of milk occurs due to bacterial fermentation, where lactose sugar is converted into lactic acid. This process results in the formation of new chemical compounds, altering the taste, odor, and chemical composition of the milk permanently. Because the original properties cannot be restored by physical means, it represents a chemical change.

5. (B) Write skeletal equation, balance atoms of each element, write physical states
Writing a balanced chemical equation follows a structured scientific protocol. First, a skeletal equation containing correct chemical formulas of reactants and products is written. Next, coefficients are added to balance the number of atoms of each element on both sides. Finally, physical states like solid, liquid, gas, or aqueous are appropriately designated.

6. (C) Creation of new atoms
During chemical reactions, existing chemical bonds break and new bonds form between atoms, resulting in product formation. However, atoms themselves are neither created nor destroyed, preserving the fundamental atomic identity and total count. Common observable indicators of chemical reactions include color changes, gas evolution, temperature fluctuations, and insoluble precipitate formation.

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7. (D) Formation of a yellow precipitate
Mixing aqueous lead nitrate with potassium iodide triggers a double displacement reaction. Insoluble lead iodide precipitates out of the liquid mixture as a distinct bright yellow solid, while potassium nitrate remains dissolved in solution. Precipitate formation and characteristic color shifts serve as classic visual evidence of double chemical precipitation reactions.

8. (A) Substance dissolved in water
In standardized chemical notation, state symbols indicate the physical phase of participating substances. The abbreviation aq stands for aqueous, denoting that a specific chemical substance is dissolved in water to form a solution. Other standard symbols include s for solid, l for liquid, and g for gas within balanced chemical equations.

9. (B) To satisfy the Law of Conservation of Mass
According to the fundamental Law of Conservation of Mass, matter can neither be created nor destroyed in a chemical reaction. Consequently, the total mass of reactants must equal the total mass of products. Balancing a chemical equation ensures that the total number

of atoms of each element remains identical on both sides.

10. (A) I and II only
Melting of wax is a physical change because it involves only a phase transition, whereas burning of wax forms carbon dioxide and water, representing a chemical change. Chemical changes always yield new substances. Dissolving sugar in water is a physical change, as sugar molecules fully retain their original chemical identity and properties.

11. (A) Calcium oxide reacting with water
A combination reaction occurs when two or more reactants combine to form a single product. When calcium oxide reacts vigorously with water, it produces calcium hydroxide as the sole product along with a large amount of heat energy. This synthetic reaction serves as a classic textbook example of a combination reaction.

12. (C) Decomposition reaction
A decomposition reaction is a chemical process in which a single compound breaks down into two or more simpler substances upon application of energy. This energy can be supplied in the form of heat, light, or electricity, driving thermal, photolytic, or electrolytic decomposition processes that break chemical bonds within reactants.

13. (D) Thermal decomposition
Heating ferrous sulphate crystals causes them to decompose into ferric oxide, sulphur dioxide, and sulphur trioxide gas. Because heat energy drives the breakdown of the single reactant into multiple simpler products, this chemical process is classified as thermal decomposition. The evolved sulphur gases produce a characteristic pungent burning odor.

14. (C) Hydrogen
When zinc granules react with dilute sulphuric acid, a single displacement reaction takes place. Zinc displaces hydrogen from the acid solution to form zinc sulphate and liberate flammable hydrogen gas. The evolution of hydrogen gas is verified by a characteristic pop sound when brought near a burning candle flame.

15. (A) P-3, Q-4, R-1, S-2
Combination reactions join elements to form one compound, like carbon and oxygen forming carbon dioxide. Decomposition splits water into hydrogen and oxygen. Single displacement involves iron displacing copper from copper sulphate solution. Double displacement exchanges ions between sodium sulphate and barium chloride, producing insoluble barium sulphate precipitate and soluble sodium chloride solution.

16. (D) Iron is more reactive than copper
In single displacement reactions, a more reactive element displaces a less reactive metal from its aqueous salt solution. Iron occupies a higher position than copper in the electrochemical reactivity series. Consequently, metallic iron displaces copper ions from copper sulphate solution, forming ferrous sulphate and precipitating reddish-brown copper metal.

17. (A) Exchange of ions between reactants
A double displacement reaction is a chemical process where two ionic compounds react in aqueous solution and exchange their constituent cations and anions to form two new compounds. Typically, one of the resulting products forms an insoluble solid precipitate, a gas, or a stable molecular compound like water during neutralisation reactions.

18. (C) Photolytic decomposition
White silver chloride decomposes into grey silver metal and chlorine gas when exposed to light energy. Because light drives the breakdown of silver chloride into simpler elemental substances, this chemical reaction is categorized as photolytic decomposition. This light-sensitive reaction forms the primary chemical basis for black and white photography.

19. (A) Addition of oxygen or removal of hydrogen
In classical chemistry, oxidation is defined as a chemical process that involves the addition of oxygen or any electronegative element to a substance, or the removal of hydrogen or any electropositive element from it. Conversely, chemical reduction represents the gain of hydrogen or loss of oxygen during a chemical transformation.

20. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Copper oxide loses oxygen to form elemental copper, undergoing reduction, while hydrogen gains oxygen to form water, undergoing oxidation. Since reduction is defined as the loss

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of oxygen and oxidation as the gain of oxygen, the provided explanation correctly accounts for the chemical changes occurring during this redox reaction.

21. (B) Oxidising agent
An oxidising agent is a chemical substance that supplies oxygen or removes hydrogen from another substance in a reaction. In doing so, the oxidising agent accepts electrons and undergoes reduction itself. Conversely, a reducing agent donates oxygen, adds hydrogen, or supplies electrons, undergoing oxidation during the redox process.

22. (C) Gain of electrons
According to the electronic concept of redox reactions, oxidation is defined as the loss of electrons by an atom, ion, or molecule, leading to an increase in oxidation state. Conversely, reduction is defined as the gain of electrons, which results in a corresponding decrease in the overall oxidation state.

23. (D) H_2S
In the reaction between hydrogen sulphide and chlorine gas, hydrogen sulphide loses hydrogen to form elemental sulphur. Since losing hydrogen constitutes oxidation, hydrogen sulphide gets oxidised. The substance that undergoes oxidation acts as the reducing agent because it supplies hydrogen to reduce chlorine gas into gaseous hydrogen chloride.

24. (A) Corrosion
Corrosion is the slow deterioration and eating away of metal surfaces caused by chemical or electrochemical reactions with atmospheric moisture, oxygen, carbon dioxide, and hydrogen sulphide. Common examples include the rusting of iron, tarnishing of silver, and formation of a green coating on exposed copper surfaces over time.

25. (A) P-3, Q-2, R-1, S-4
Iron corrodes to form reddish-brown hydrated ferric oxide, commonly known as rust. Copper reacts with atmospheric gases to form a protective green basic copper carbonate coating. Silver tarnishes into black silver sulphide upon exposure to sulphur traces. Aluminium forms a thin, tough, dull white surface layer of protective aluminium oxide.

26. (B) $Fe_2O_3.xH_2O$
Rust is a complex hydrated chemical compound formed when iron reacts with oxygen and water vapor in the atmosphere. Its precise chemical representation is hydrated ferric oxide, written as $Fe_2O_3.xH_2O$, where x represents a variable number of water molecules bound within the crystal lattice structure of the rust layer.

27. (A) Galvanisation
Galvanisation is an industrial anti-corrosion technique that involves applying a thin protective layer of molten zinc onto iron or steel objects. Zinc acts as a sacrificial metal because it corrodes preferentially even if the outer coating is scratched, preventing atmospheric oxygen and moisture from reaching the underlying iron surface.

28. (C) Rancidity
Rancidity refers to the slow chemical oxidation of fats and oils present in food items when exposed to atmospheric oxygen, heat, or light over extended periods. This oxidative degradation produces volatile aldehydes and carboxylic acids, resulting in unpleasant odors, disagreeable tastes, and spoiled quality of stored food products.

29. (D) Nitrogen
Nitrogen is an unreactive, inert gas used by food packaging manufacturers to flush sealed bags of potato chips and snacks. By displacing reactive atmospheric oxygen, nitrogen prevents the oxidative degradation of fats and oils, thereby inhibiting rancidity and extending the shelf life and crispiness of packaged food items.

30. (B) I and III only
Oxidation increases an element's oxidation number through the loss of electrons, while reduction decreases it. A reducing agent donates electrons and undergoes oxidation, not reduction. Oxidation and reduction occur simultaneously in redox reactions because electron loss by one species must equal electron gain by another species in the chemical system.

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31. (B) Catalyst
A catalyst is a chemical substance that alters the rate of a chemical reaction without itself undergoing any permanent chemical or quantitative change. It works by providing an alternative reaction path with a different activation energy, thereby accelerating or

decelerating the rate while remaining chemically intact after reaction completion.

32. (D) By providing a lower activation energy pathway
A positive catalyst accelerates the rate of a chemical reaction by offering an alternative mechanism that possesses a lower activation energy barrier. By lowering the energy threshold, a higher fraction of colliding reactant molecules possess sufficient kinetic energy to overcome the energy barrier and successfully form product molecules per second.

33. (A) Glycerol
Negative catalysts, or inhibitors, decrease the rate of a chemical reaction by increasing the activation energy or interfering with reaction intermediates. Glycerol acts as a negative catalyst that retards the spontaneous decomposition of hydrogen peroxide into water and oxygen gas, increasing the stability and shelf life of the solution.

34. (C) Nitrogenous proteins
Enzymes are complex biological catalysts composed of high molecular weight nitrogenous protein molecules produced by living cells. They accelerate biochemical reactions within biological systems with extreme specificity and efficiency, operating under mild physiological temperatures and optimal pH conditions essential for maintaining metabolic pathways in living organisms.

35. (A) P-2, Q-1, R-4, S-3
Industrial processes utilize specific catalysts to optimize reaction yields. Finely divided iron catalyses ammonia synthesis in the Haber process. Vanadium pentoxide or platinised asbestos catalyses sulphur dioxide oxidation in the Contact process. Nickel catalyses vegetable oil hydrogenation, while platinum gauze catalyses ammonia oxidation in the Ostwald process for nitric acid production.

36. (D) Catalyst promoter
A catalyst promoter is a chemical substance that is not a catalyst itself but enhances the activity and catalytic efficiency of a catalyst when added in small quantities. It alters the surface structure or electronic properties of the catalyst, thereby increasing the active site efficiency during industrial chemical transformations.

37. (B) Molybdenum
In the industrial Haber process for ammonia synthesis, finely divided iron acts as the principal heterogenous catalyst. Molybdenum is added as a promoter to enhance the catalytic performance of iron. It expands the lattice structure of iron, thereby increasing the available active surface area for nitrogen and hydrogen adsorption.

38. (C) The catalyst and reactants are in the same phase
Homogeneous catalysis occurs when the catalyst and the reacting substances exist together in a single uniform physical phase, such as all liquids or all gases. A classic example is the oxidation of sulphur dioxide gas to sulphur trioxide gas catalysed by gaseous nitric oxide in the lead chamber process.

39. (D) Heterogeneous catalysis
Heterogeneous catalysis occurs when the catalyst exists in a physical phase different from that of the reacting substances. In the commercial hydrogenation of vegetable oils, gaseous hydrogen and liquid oil react on the surface of solid finely divided nickel catalyst, demonstrating a classic multi-phase heterogeneous catalytic system.

40. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Enzymes exhibit remarkable specificity in their biological catalytic activity, with a given enzyme acting only on a specific substrate. This high specificity stems from the unique three-dimensional conformation of the enzyme active site, which perfectly complements the substrate structure according to the classic lock-and-key model of enzyme action.

41. (B) Oxidation of oxalic acid by potassium permanganate
Auto-catalysis is a process where one of the products formed during a chemical reaction acts as a catalyst for that same reaction. In the titration of oxalic acid with potassium permanganate, manganese ions produced during the initial reaction act as an auto-catalyst, significantly accelerating the reaction speed as it proceeds.

42. (B) Induced catalysis
Induced catalysis occurs when a chemical reaction that normally does not take place under standard conditions is induced to occur by the

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simultaneous occurrence of another chemical reaction. The energy or active intermediates generated by the primary reaction lower the barrier for the non-spontaneous reaction, allowing both to proceed together.

43. (A) Zymase
Zymase is a complex enzyme mixture secreted naturally by yeast cells during anaerobic fermentation. It catalyses the biological conversion of simple hexose sugars, such as glucose and fructose, into ethanol and carbon dioxide gas. This biochemical process forms the primary chemical basis for industrial alcohol production and brewing industries.

44. (C) Honeycomb pore structure
Zeolites are microporous aluminosilicate minerals characterized by a highly ordered three-dimensional honeycomb pore structure. Their catalytic action depends strictly on the pore dimensions and cavity sizes, allowing only molecules of specific size and shape to enter, react, and exit, making them effective shape-selective catalysts in industrial petrochemical processes.

45. (A) P-3, Q-1, R-2, S-4
Specific enzymes catalyse distinct biological conversions. Invertase hydrolyses cane sugar into glucose and fructose. Urease decomposes urea into ammonia and carbon dioxide. Pepsin breaks down complex proteins into shorter peptide chains in gastric fluid, while salivary amylase converts complex dietary starch into the simpler disaccharide maltose.

46. (C) Exothermic reaction
An exothermic reaction is a chemical process accompanied by the net release of energy, usually in the form of heat, light, or sound. In these reactions, the total enthalpy of the reactants is higher than that of the products, resulting in a negative enthalpy change and temperature rise in surroundings.

47. (B) Exothermic
Respiration is a biochemical combustion process occurring in living cells, where glucose reacts with inhaled oxygen to form carbon dioxide, water, and energy stored as adenosine triphosphate. Because energy is liberated in the form of chemical energy and thermal heat to sustain life, respiration is classified as an exothermic reaction.

48. (D) Endothermic reaction
An endothermic reaction is a chemical process that absorbs thermal energy from its immediate surroundings to proceed. In such reactions, the total energy required to break bonds in reactants exceeds the energy released during product formation, resulting in a positive change in enthalpy and a drop in surrounding temperature.

49. (A) Photosynthesis in plants
Photosynthesis is a key endothermic process in which green plants absorb light energy from sunlight to synthesize glucose and oxygen gas from carbon dioxide and water. Energy absorption is mandatory to break strong chemical bonds, making it fundamentally distinct from exothermic processes like fuel combustion or cellular respiration.

50. (B) II and III only
A catalyst alters reaction speed by providing a lower activation energy path but does not initiate non-spontaneous reactions nor change the thermodynamic equilibrium constant. Biocatalysts like enzymes operate optimally at specific physiological temperatures and pH levels, losing catalytic efficiency outside these narrow operational limits due to structural denaturation.

51. (A) Combustion
Combustion is a rapid exothermic chemical reaction between a fuel substance and atmospheric oxygen gas that produces oxidized products accompanied by the evolution of heat energy and light. Complete combustion of hydrocarbons yields carbon dioxide and water vapor, whereas incomplete combustion produces toxic carbon monoxide and soot particles.

52. (D) Carbon monoxide
Incomplete combustion occurs when carbon-containing fuels burn in a restricted supply of oxygen. This partial oxidation yields carbon monoxide, a colorless, odorless, and highly toxic gas. Carbon monoxide binds strongly to hemoglobin in blood, forming carboxyhemoglobin, which drastically reduces the overall oxygen-carrying capacity of human blood.

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53. (B) Neutralisation
A neutralisation reaction occurs when an acid reacts quantitatively with a base to form a salt and water. Hydronium ions from the acid combine with hydroxide ions from the base to yield neutral water molecules. This process is generally exothermic and eliminates both acidic and basic character from solution.

54. (C) Neutral
When a strong acid reacts with an equivalent amount of a strong base, both dissociate completely in aqueous solution. The resulting salt consists of ions that do not undergo hydrolysis in water. Consequently, the concentration of hydrogen ions equals hydroxide ions, maintaining a neutral pH of exactly 7.

55. (A) P-2, Q-1, R-3, S-4
Chemical processes involve characteristic enthalpy changes. Burning coal and acid-base neutralisation between sodium hydroxide and hydrochloric acid release substantial heat energy, making them exothermic processes. Conversely, dissolving ammonium chloride in water and thermally decomposing calcium carbonate absorb energy from surroundings, classifying them as endothermic chemical reactions.

56. (A) Precipitation reaction
A precipitation reaction occurs when two soluble ionic compounds in aqueous solution react to form an insoluble solid product known as a precipitate. This solid separates from the liquid solution due to low solubility product values, providing a distinct physical indicator of chemical double displacement processes in solution.

57. (B) White
The reaction between aqueous sodium sulphate and barium chloride is a classic double displacement reaction. Barium ions combine with sulphate ions to form barium sulphate, an insoluble white solid precipitate that immediately separates from solution, while soluble sodium chloride remains completely dissolved in the surrounding aqueous liquid phase.

58. (B) Decomposition
Digestion of food is a complex biological decomposition process where large, insoluble macromolecular nutrients like carbohydrates, proteins, and lipids are broken down into smaller, simpler, soluble molecules like glucose, amino acids, and fatty acids through enzymatic hydrolysis reactions occurring continuously along the human gastrointestinal tract.

59. (A) Exothermic reaction
The decomposition of organic waste materials into compost by microorganisms is an exothermic biochemical reaction. Microbes break down complex organic compounds into simpler nutrients through aerobic oxidation, releasing energy in the form of heat. This released heat causes the overall temperature of composting piles to rise significantly during active decomposition.

60. (C) Assertion (A) is true but Reason (R) is false.
Adding water to concentrated sulphuric acid releases a substantial quantity of heat energy, making the dilution process strongly exothermic. Dilution of strong acids involves hydration of ions, which releases heat rather than absorbing it. Therefore, the assertion correctly identifies heat release, while the reason incorrectly states that heat is absorbed.

61. (D) Increasing reactant surface area
Increasing the surface area of solid reactants exposes more active surface particles to collisions with reactant molecules per unit time. This higher effective contact area increases the overall collision frequency between reacting species, thereby significantly accelerating the overall rate of reaction according to fundamental chemical kinetic principles.

62. (C) It exposes a larger surface area
Powdering a solid reactant breaks large particles into smaller fragments, drastically expanding the exposed total surface area. A larger surface area allows more reactant particles to interact and collide simultaneously per second, thereby increasing effective collision frequency and substantially elevating the overall speed of the chemical reaction.

63. (B) More molecules gain energy exceeding activation energy
According to collision theory, raising the temperature increases the average kinetic energy of reactant molecules. Consequently, a significantly larger fraction of colliding particles possess kinetic energy equal to or greater than the activation energy barrier, leading to a higher proportion of fruitful, product-forming collisions per unit time overall.

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64. (D) Activation energy
Activation energy is defined as the minimum additional amount of energy required by reactant molecules to convert their initial thermal kinetic energy into the threshold energy state. Supplying this minimum energy enables reacting species to overcome the potential energy barrier and form the unstable activated complex during a chemical reaction.

65. (A) P-3, Q-4, R-1, S-2
In electronic redox terminology, oxidation is the loss of electrons, while reduction is the gain of electrons. An oxidising agent causes oxidation by gaining electrons from another species during the reaction. Conversely, a reducing agent causes reduction by donating electrons, undergoing oxidation itself in the overall balanced chemical process.

66. (C) Hydrochloric acid
Hydrochloric acid is secreted by parietal cells in the gastric glands of the stomach mucosa. It maintains a strongly acidic gastric pH between 1.5 and 3.5, which converts inactive pepsinogen into active pepsin enzyme, facilitates protein digestion, and destroys harmful ingested pathogens entering the human digestive tract.

67. (A) Gives hydrogen ions (H^+) in aqueous solution
According to the classic Arrhenius theory of acids and bases, an acid is defined as a neutral compound that dissociates in aqueous solution to yield hydrogen ions as the only cations. Because free hydrogen ions combine with water molecules, they exist as hydronium ions in aqueous chemical systems.

68. (D) Produces OH- ions in water
According to the Arrhenius concept, a base is a substance that dissociates in aqueous solution to generate hydroxide ions as the sole anionic species. Sodium hydroxide and potassium hydroxide are classic Arrhenius bases because they yield free hydroxide ions upon dissolution in water, turning red litmus paper blue consistently.

69. (B) Blue to Red
Litmus is a naturally derived acid-base indicator extracted from lichens. In acidic solutions containing elevated hydrogen ion concentrations, blue litmus paper undergoes a structural chemical transformation, resulting in a distinct color change from blue to red. Conversely, basic solutions convert red litmus paper back to blue.

70. (A) I and II only
The pH scale quantitatively measures hydrogen ion concentration in solution, where a pH of 7 represents a neutral state at room temperature. The pH value is inversely proportional to hydronium ion concentration; thus, higher hydronium ion concentrations correspond to lower pH values, making the third statement scientifically incorrect.

71. (D) Power
The term pH was introduced by Sorensen, where 'p' stands for 'potenz', a German word meaning power, and 'H' denotes hydrogen ion concentration. Mathematically, pH is defined as the negative logarithm to base ten of the hydrogen ion activity or concentration in an aqueous chemical solution overall.

72. (B) 7.0 to 7.8
Human physiological systems maintain arterial blood and extracellular fluid within a narrow, slightly basic pH range of 7.0 to 7.8, strictly regulated around 7.4. Enzyme activity, cellular function, and metabolic pathways require this precise pH range, as significant deviations disrupt normal homeostatic mechanisms and cellular survival.

73. (C) 5.6
Unpolluted rainwater is naturally slightly acidic with a pH around 5.6 due to dissolved atmospheric carbon dioxide forming weak carbonic acid. When atmospheric pollutants like sulphur dioxide and nitrogen oxides dissolve in rainwater to form sulphuric and nitric acids, precipitation pH drops below 5.6, defining true acid rain.

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74. (C) 5.5
Tooth enamel is composed of calcium hydroxyapatite, a crystalline form of calcium phosphate. When bacteria in the mouth degrade dietary sugars, they produce organic acids. If oral pH drops below 5.5, the acidic environment causes active demineralization and gradual dissolution of tooth enamel, leading directly to tooth decay.

75. (A) P-2, Q-1, R-3, S-4
Everyday substances exhibit characteristic pH levels. Pure water is neutral with a pH of

7. Lemon juice contains citric acid, giving it a strongly acidic pH around 2. Human blood is slightly basic with a pH of approximately 7.4. Milk of Magnesia is a basic suspension with a pH around 10.

76. (C) Mild bases
Antacids are pharmacological agents formulated from mild basic compounds like magnesium hydroxide or sodium hydrogen carbonate. They react with excess hydrochloric acid secreted in the stomach during hyperacidity, performing a neutralisation reaction that forms salt and water, thereby relieving pain and irritation without damaging delicate gastric tissues.

77. (D) Methanoic acid
A bee sting injects methanoic acid, commonly called formic acid, into the human skin tissue. This acid causes localized inflammation, sharp pain, and itching. Neutralizing the injected acid by applying a mild base like baking soda provides immediate relief by forming a neutral salt and water at the affected area.

78. (C) Basic
Nettle leaf hair stings inject methanoic acid into skin tissue, causing burning sensation and severe pain. Rubbing the affected area with dock plant leaves neutralises the acidity, indicating that dock plant sap contains basic alkaline compounds. Neutralisation neutralises the acid, thereby alleviating pain and soothing skin inflammation effectively overall.

79. (B) Sodium hydrogen carbonate
Baking soda is chemically known as sodium hydrogen carbonate or sodium bicarbonate, possessing the chemical formula $NaHCO_3$. Produced via the Solvay process using sodium chloride, carbon dioxide, ammonia, and water, it acts as a mild non-corrosive basic salt widely used as a leavening agent in baking and as an antacid.

80. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Plaster of Paris, chemically calcium sulphate hemihydrate, readily absorbs environmental moisture and combines with water to form hydrated calcium sulphate, known as gypsum. Gypsum sets rapidly into a hard, solid, inflexible mass. Therefore, Plaster of Paris must be stored in moisture-proof containers to prevent premature hydration and degradation overall.

81. (A) Chlor-alkali process
Industrial production of sodium hydroxide involves the electrolysis of concentrated aqueous sodium chloride, known as brine, in a specialized cell. This process is called the chlor-alkali process because it yields chlorine gas at the anode, hydrogen gas at the cathode, and sodium hydroxide, an alkali, in the solution.

82. (C) Chlorine
During the chlor-alkali electrolysis of aqueous sodium chloride, chloride ions undergo oxidation at the positively charged anode to release chlorine gas. Concurrently, water molecules undergo reduction at the negatively charged cathode to generate hydrogen gas, while sodium and hydroxide ions remain in solution to form sodium hydroxide overall.

83. (A) Dry calcium hydroxide
Bleaching powder, chemically calcium oxychloride with formula $CaOCl_2$, is manufactured industrially by passing dry chlorine gas over dry slaked lime, which is calcium hydroxide. This gas-solid chemical reaction produces calcium oxychloride along with water, yielding a compound widely utilized for textile bleaching and water disinfection purposes.

84. (D) $Na_2CO_3.10H_2O$
Washing soda is chemically designated as sodium carbonate decahydrate, represented by the chemical formula $Na_2CO_3.10H_2O$. Recrystallization of anhydrous sodium carbonate from water yields crystals containing ten molecules of water of crystallisation per formula unit, giving washing soda its basic character and utility in removing water hardness effectively.

85. (A) P-2, Q-4, R-1, S-3
Common chemical compounds possess defined standardized chemical formulas. Bleaching powder is calcium oxychloride, $CaOCl_2$. Baking soda is sodium hydrogen carbonate, $NaHCO_3$. Washing soda is sodium carbonate decahydrate, $Na_2CO_3.10H_2O$. Plaster of Paris is calcium sulphate hemihydrate, $CaSO_4.1/2H_2O$, formed by controlled thermal dehydration of gypsum mineral.

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86. (B) 5
Hydrated copper sulphate crystals, chemically named copper sulphate pentahydrate, possess five molecules of water of crystallisation per formula unit, represented as $CuSO_4.5H_2O$. These bound water molecules impart a characteristic blue color to the crystalline solid, which turns white upon heating due to complete loss of hydration water content.

87. (D) Plaster of Paris
Heating gypsum, which is calcium sulphate dihydrate ($CaSO_4.2H_2O$), at 373 K causes it to lose three-quarters of its water of crystallisation. This controlled thermal dehydration produces calcium sulphate hemihydrate ($CaSO_4.1/2H_2O$), commonly known as Plaster of Paris, widely used for setting fractured bones and making decorative casts overall.

88. (A) Magnesium hydroxide
Milk of Magnesia is an aqueous suspension of magnesium hydroxide, $Mg(OH)_2$. Acting as a mild basic substance, it is orally administered as an antacid to counteract hyperacidity in the human stomach. It neutralises excessive gastric hydrochloric acid to form magnesium chloride and water, relieving heartburn safely without irritation.

89. (B) Turmeric
Turmeric is a naturally occurring acid-base indicator containing the yellow pigment curcumin. In neutral and acidic solutions, turmeric retains its bright yellow color. However, when brought into contact with basic or alkaline solutions like soap or sodium hydroxide, turmeric undergoes a chemical change and turns reddish-brown noticeably.

90. (A) I and II only
Hydrochloric acid ionises completely in water, producing high hydronium ion concentration, making it a strong acid. Acetic acid ionises only partially, leaving un-ionised molecules in equilibrium, making it a weak acid. Strong acids have higher hydronium ion concentrations and lower pH values than weak acids at identical molar concentrations.

91. (A) Acidic
When a strong acid reacts with a weak base, the resulting salt undergoes salt hydrolysis in aqueous solution. The conjugate acid of the weak base reacts with water to produce excess hydronium ions. Consequently, the solution exhibits an acidic nature with a pH value less than 7 at equilibrium.

92. (C) Platinum-Rhodium
Catalytic converters in modern automobile exhaust systems utilize precious transition metals like platinum, rhodium, and palladium as heterogeneous catalysts. These metals catalyze the oxidation of unburnt toxic hydrocarbons and carbon monoxide into carbon dioxide and water, while simultaneously reducing harmful nitrogen oxides into non-toxic nitrogen gas efficiently.

93. (D) Acids
Acids are chemical compounds characterized organoleptically by a distinct sour taste. Lemon juice tastes sour due to the presence of naturally occurring organic acids, primarily citric acid and ascorbic acid. These chemical acids donate hydrogen ions in solution, which stimulate acid-sensitive taste receptors on the human tongue directly.

94. (C) Pink
Phenolphthalein is a synthetic acid-base indicator that remains colorless in acidic and neutral aqueous solutions. When added to a basic solution where the pH exceeds 8.2, phenolphthalein molecules undergo structural deprotonation, transforming into an anionic conjugate form that imparts a deep pink color to the alkaline mixture overall.

95. (B) Iron, Zinc, Magnesium, Potassium
The reactivity series arranges metals in order of decreasing chemical activity. Iron is moderately reactive, zinc is more reactive than iron, magnesium is more reactive than zinc, and potassium is an alkali metal located near the top of the reactivity series, exhibiting the highest chemical reactivity among the group listed.

96. (D) Reversible reactions
A reversible reaction is a chemical process where reactants react to form products, and simultaneously, products react to regenerate the original reactants. These reactions proceed in both forward and backward directions until dynamic equilibrium is established, where forward and reverse reaction rates become equal in a closed chemical system overall.

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97. (A) Accelerate both forward and backward reactions equally
In a reversible chemical system, adding a catalyst lowers the activation energy for both forward and reverse reactions by an identical amount. Consequently, it accelerates forward and backward reaction rates equally, allowing the system to reach chemical equilibrium much faster without shifting the equilibrium position or changing final product yields.

98. (C) Basic copper carbonate
When copper metal is exposed to moist air over long periods, it slowly reacts with atmospheric oxygen, carbon dioxide, and water vapor. This corrosion process produces a dull green coating on the surface, which chemically consists of basic copper carbonate, a mixture of copper hydroxide and copper carbonate, $CuCO_3.Cu(OH)_2$ overall.

99. (A) Adding yeast to dough
Yeast cells contain biological enzymes like zymase and invertase that act as biocatalysts during baking. Adding yeast to dough accelerates the fermentation of sugars into ethanol and carbon dioxide gas. The trapped carbon dioxide causes dough to rise and become light and porous, demonstrating an everyday practical application of catalysis.

100. (D) Salivary amylase
Salivary amylase, also known as ptyalin, is a digestive enzyme secreted by salivary glands into the oral cavity. It catalyses the preliminary breakdown of dietary starch, a complex polysaccharide, into simpler disaccharides like maltose. This enzymatic hydrolysis represents the initial chemical phase of carbohydrate digestion in human beings.

101. (B) Oxidation
According to classical chemical definitions, oxidation includes processes involving the addition of oxygen or any non-metallic electronegative element to a substance, or the removal of hydrogen or electropositive metallic elements. Conversely, reduction involves adding metallic electropositive elements or removing non-metallic electronegative elements from a given chemical compound overall.

102. (C) Collision theory
Collision theory explains that chemical reactions occur when reactant particles collide with sufficient activation energy and proper orientation. Increasing reactant concentration increases the total number of solute particles per unit volume, leading to a higher frequency of successful collisions per second and accelerating the reaction rate significantly.

103. (D) Applying a coating of paint
Applying a uniform coat of paint to large iron structures like bridges creates an impermeable physical barrier. This barrier prevents atmospheric moisture and oxygen gas from coming into direct physical contact with the metallic iron surface, effectively preventing the electrochemical corrosion process responsible for iron rusting over time.

104. (A) Baking of a cake
Baking a cake involves complex irreversible chemical changes, such as protein denaturation, thermal decomposition of leavening agents, and starch gelatinization driven by heat energy. New chemical compounds with distinct properties are produced, preventing the cake from being converted back into its original raw ingredients through simple physical methods overall.

105. (B) Physical state of substances never changes in a chemical reaction
During chemical reactions, the physical states of substances frequently change, such as gaseous water forming liquid water or solid reactants producing gaseous products. Atomic identities and total mass are conserved, and individual atoms do not transmute into different elements, making the assertion that physical states never change scientifically false.

106. (B) Stoichiometric coefficient
In a balanced chemical equation, numbers written directly before chemical formulas are called stoichiometric coefficients. The integer '2' placed before H_2O indicates two complete water molecules or two moles of water participating in the reaction, serving to balance the total count of individual hydrogen and oxygen atoms overall.

107. (A) Silver bromide
Silver bromide is a light-sensitive ionic compound extensively used in photographic film emulsions. When exposed to light during photography, silver bromide undergoes photolytic decomposition into solid silver particles and bromine gas. The precipitated microscopic silver grains form the

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developed dark image on photographic plates in black and white photography overall.

108. (C) It releases energy in the form of ATP and heat
Cellular respiration is classified as an exothermic reaction because it involves the metabolic oxidation of glucose in the presence of oxygen, forming carbon dioxide and water. This metabolic process liberates energy, which is stored chemically as adenosine triphosphate and released as thermal heat energy to sustain essential biological processes.

109. (D) Crystallisation of salt
Crystallisation of salt from an aqueous solution is a physical change because it involves removing solvent water molecules without altering the fundamental chemical structure or formula of sodium chloride. No new chemical compounds are produced, and dissolving the solid crystals back in pure water completely restores the original solution state.

110. (C) Hydrochloric acid
A solution turning red litmus blue is basic in nature. Adding excess hydrochloric acid, a strong acid, neutralises the basic hydroxide ions and makes the solution acidic. In the resulting acidic environment containing excess hydronium ions, the indicator undergoes a structural shift, reversing the color back to red effectively.

111. (B) Oxalic acid
Tomatoes are natural plant sources containing various organic dicarboxylic acids, with oxalic acid being the most abundant acid present alongside smaller amounts of citric acid. Oxalic acid imparts mild tartness to ripe tomatoes and forms insoluble calcium oxalate salts when combined with dietary calcium in physiological systems overall.

112. (D) Quicklime (Calcium oxide)
Highly acidic soil impairs plant growth by decreasing nutrient availability. Adding quicklime, which is basic calcium oxide, performs an acid-base neutralisation reaction with hydrogen ions in the soil solution. This reaction neutralises soil acidity, raising the soil pH to an optimal level required for healthy crop development overall.

113. (A) 1
Hydrochloric acid is a strong monoprotic acid that dissociates completely in water. A 0.1 molar solution yields a hydronium ion concentration of 10^{-1} moles per liter. Calculating pH using the logarithmic formula $pH = -\log[H^+]$ gives $-\log(10^{-1})$, resulting in an acidic pH value of exactly 1.

114. (C) Potassium nitrate
Reacting potassium hydroxide, a strong base, with nitric acid, a strong acid, results in a neutralisation reaction. Hydroxide ions from potassium hydroxide combine with hydrogen ions from nitric acid to form neutral water, while potassium cations and nitrate anions join to yield the neutral salt potassium nitrate overall.

115. (A) II, IV, III, I
Arranging aqueous solutions by increasing pH means ordering from most acidic to most basic. Gastric juice is strongly acidic (pH ~1.5 to 3.0), pure water is neutral (pH = 7.0), human blood is slightly basic (pH ~7.4), and Milk of Magnesia is basic (pH ~10.5), yielding the sequence II, IV, III, I.

116. (D) Weak acid and strong base
A basic salt is produced when a weak acid reacts with a strong base during neutralisation. In aqueous solution, the conjugate base of the weak acid undergoes hydrolysis, reacting with water to yield excess hydroxide ions. This anion hydrolysis increases hydroxide concentration, raising the pH above 7 overall.

117. (B) Lactic acid
Curd is formed through the bacterial fermentation of milk by Lactobacillus bacteria. These microorganisms convert lactose, the natural disaccharide sugar present in milk, into lactic acid. Lactic acid lowers the pH, causing milk proteins to coagulate into curd, imparting its characteristic sour flavor and thick texture overall.

118. (C) They act as reducing agents preventing oxidation
Antioxidants are chemical preservatives added to fatty foods to retard oxidative spoilage. Acting as reducing agents, antioxidants undergo preferential oxidation by scavenging reactive free radicals and oxygen molecules. This sacrificial protection prevents the oxidative degradation of fats and oils, effectively maintaining food freshness and preventing rancidity overall.

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119. (D) To increase the electrical conductivity of water

Pure distilled water is a poor conductor of electricity because it contains extremely low concentrations of free hydronium and hydroxide ions from self-ionisation. Adding a small quantity of dilute sulphuric acid supplies free mobile ions in high concentrations, significantly increasing electrical conductivity and enabling efficient water electrolysis overall.

120. (A) II, I, IV, III

Galvanisation follows a specific sequential process. First, the iron surface is thoroughly cleaned to remove rust, grease, and impurities. Second, the cleaned iron article is submerged into a molten zinc bath. Third, a protective zinc layer forms on the iron surface. Finally, the coated article is cooled to solidify the zinc.

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CHAPTER 02

Metals, Non-metals and Their Compounds

1. The physical property of metals that allows them to be beaten into thin sheets without breaking is known as:
(A) Ductility
(B) Malleability
(C) Sonority
(D) Conductivity

2. Which of the following is the only non-metal that exists as a liquid at standard room temperature?
(A) Mercury
(B) Iodine
(C) Chlorine
(D) Bromine

3. What is the fundamental difference in the chemical nature of oxides formed by metals and non-metals?
(A) Metal oxides are basic, whereas non-metal oxides are acidic.
(B) Metal oxides are acidic, whereas non-metal oxides are basic.
(C) Both metal and non-metal oxides are generally neutral.
(D) Metal oxides are neutral, whereas non-metal oxides are amphoteric.

4. According to the reactivity series, which of the following displacement reactions is chemically feasible?
(A) Copper displacing iron from iron sulphate solution
(B) Silver displacing zinc from zinc nitrate solution
(C) Zinc displacing copper from copper sulphate solution
(D) Lead displacing magnesium from magnesium chloride solution

5. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Sodium metal is kept immersed in kerosene oil.
Reason (R): Sodium is a highly reactive metal that catches fire when exposed to oxygen and moisture in the air.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

6. Aluminium reacts with oxygen to form aluminium oxide (Al_2O_3). What is the specific chemical nature of aluminium oxide?
(A) Purely acidic
(B) Purely basic
(C) Neutral
(D) Amphoteric

7. When calcium is dropped into water, it reacts less violently than sodium and starts floating. What causes the calcium to float?
(A) Calcium becomes less dense than water upon contact.
(B) Bubbles of hydrogen gas stick to the surface of the metal.
(C) Bubbles of oxygen gas form a buoyant layer around it.
(D) A highly porous layer of calcium hydroxide is formed instantly.

8. Which of the following elements is classified as a metalloid due to exhibiting properties intermediate between metals and non-metals?
(A) Bismuth
(B) Lead
(C) Silicon
(D) Carbon

9. In the extraction of metals, the process of heating a sulphide ore strongly in the presence of excess air is known as:
(A) Calcination
(B) Smelting
(C) Refining
(D) Roasting

10. Consider the following statements regarding ores and minerals:
I. All minerals are ores.

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II. All ores are minerals.
III. An ore is a mineral from which a metal can be extracted profitably.
Which of the above combinations is correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

11. Brass is a widely used alloy in everyday objects. What are the constituent metals of brass?
(A) Copper and Tin
(B) Copper and Zinc
(C) Lead and Tin
(D) Iron and Chromium

12. What is the correct chemical formula for Baking Soda, a common household compound?
(A) Na_2CO_3
(B) $NaHCO_3$
(C) NaOH
(D) NaCl

13. The chemical formula of Gypsum is:
(A) $CaSO_4.2H_2O$
(B) $CaSO_4.1/2H_2O$
(C) $CaCO_3$
(D) $CaCl_2.2H_2O$

14. Which of the following is NOT a standard use of Washing Soda (Sodium carbonate)?
(A) Used in glass, soap, and paper industries
(B) Used for the removal of permanent hardness of water
(C) Used as an antacid in medicine
(D) Used as a cleansing agent for domestic purposes

15. Match the chemical compounds in List I with their common names in List II:
List I: (Chemical Compound)
P. Calcium oxide
Q. Calcium hydroxide
R. Calcium sulphate hemihydrate
S. Calcium hypochlorite
List II: (Common Name)
1. Slaked lime
2. Quicklime
3. Bleaching powder
4. Plaster of Paris
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-4, R-1, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-1, R-4, S-3

16. At what specific temperature must gypsum be heated to carefully form Plaster of Paris?
(A) 273 K
(B) 473 K
(C) 373 K
(D) 173 K

17. Alum (Phitkari) is commonly used in everyday life for which of the following primary purposes?
(A) As an antacid for stomach relief
(B) For the purification of muddy water
(C) As a preservative in canned foods
(D) For removing permanent hardness of water

18. Bleaching powder is synthesized in industries by the action of chlorine gas on which of the following substances?
(A) Quicklime
(B) Calcium carbonate
(C) Calcium sulphate
(D) Dry slaked lime

19. Galvanisation is a specific method used to protect iron from rusting. It involves coating the iron with a thin layer of:
(A) Zinc
(B) Copper
(C) Tin
(D) Chromium

20. Select the correct decreasing order of reactivity for the following metals:
(A) Potassium > Sodium > Calcium > Magnesium
(B) Sodium > Potassium > Magnesium > Calcium
(C) Calcium > Potassium > Sodium > Magnesium
(D) Magnesium > Calcium > Sodium > Potassium

21. Which non-metal is applied on wounds as an antiseptic in the form of a purple-coloured solution known as its tincture?
(A) Iodine
(B) Sulphur
(C) Bromine
(D) Phosphorus

22. In the context of chemical fertilisers, what does the commonly used abbreviation "NPK" stand for?
(A) Nitrogen, Phosphorus, Krypton
(B) Nickel, Phosphorus, Potassium
(C) Nitrogen, Palladium, Potassium

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(D) Nitrogen, Phosphorus, Potassium

23. Which of the following compounds is a primary raw material used extensively in the manufacturing of Portland cement?
(A) Sodium bicarbonate
(B) Limestone
(C) Sodium chloride
(D) Ammonium nitrate

24. What is the main chemical constituent used as the structural former in the manufacturing of standard glass?
(A) Calcium carbonate
(B) Sodium carbonate
(C) Silica
(D) Lead oxide

25. Match the metals in List I with their principal ores in List II:
List I: (Metal)
P. Aluminium
Q. Iron
R. Zinc
S. Mercury
List II: (Principal Ore)
1. Cinnabar
2. Bauxite
3. Haematite
4. Calamine
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-3, R-4, S-1

26. Zinc oxide (ZnO) is widely used in various industries. It is historically known by which of the following names?
(A) Philosopher's wool
(B) Lunar caustic (silver nitrate)
(C) Blue vitriol (copper sulphate)
(D) Green vitriol (iron sulphate)

27. The industrial process used for the production of sodium hydroxide by the electrolysis of aqueous sodium chloride is known as:
(A) Industrial Haber process
(B) Chlor-alkali process
(C) Industrial Contact process
(D) Industrial Solvay process

28. Silver articles turn black after some time when exposed to air. This is due to the formation of a coating of:
(A) Silver oxide
(B) Silver sulphide
(C) Silver carbonate
(D) Silver chloride

29. Copper vessels exposed to moist air acquire a dull green coating over time. This green material is a mixture of:
(A) Copper hydroxide and Copper carbonate
(B) Copper oxide and Copper sulphide mixture
(C) Copper chloride and Copper hydroxide mixture
(D) Copper sulphate and Copper oxide mixture

30. Consider the following combinations regarding the composition of alloys:
I. Bronze: Copper and Tin
II. Solder: Lead and Tin
III. Stainless Steel: Iron, Carbon, Chromium, and Nickel
Which of the combinations given above is/are correct?
(A) I only
(B) I and II only
(C) II and III only
(D) I, II, and III

31. Among the following metals, which is the best conductor of electricity?
(A) Gold
(B) Copper
(C) Aluminium
(D) Silver

32. Non-metals are generally non-lustrous. However, which of the following non-metals is an exception and possesses a natural metallic lustre?
(A) Sulphur
(B) Phosphorus
(C) Iodine
(D) Carbon

33. Which allotrope of a non-metal is recognized as the hardest naturally occurring substance known?
(A) Graphite
(B) Diamond
(C) Fullerene
(D) Boron carbide

34. When a reactive metal reacts with a dilute strong acid, a gas is generally evolved. What is the standard test for this gas?
(A) It turns lime water milky.
(B) It relights a glowing splint.
(C) It turns acidified potassium dichromate

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paper green.
(D) It burns with a characteristic pop sound.

35. Hydrogen gas is generally not evolved when metals react with dilute nitric acid (HNO_3). What is the primary reason for this?
(A) It is a strong oxidising agent that oxidises hydrogen to water.
(B) Nitric acid acts as a weak acid that is unable to displace hydrogen gas from metals.
(C) Nitric acid acts primarily as a strong reducing agent in aqueous chemical reactions.
(D) Metals become completely passive instantly upon contact without undergoing reaction.

36. Aqua regia, a highly corrosive fuming liquid capable of dissolving gold, is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of:
(A) 1 : 3
(B) 2 : 2
(C) 3 : 1
(D) 1 : 2

37. The reaction of iron(III) oxide (Fe_2O_3) with aluminium is highly exothermic and is used to join railway tracks or cracked machine parts. This process is known as the:
(A) Thermite reaction
(B) Goldschmidt reaction
(C) Roasting process
(D) Electrolytic reduction

38. During the electrolytic refining of copper, the insoluble impurities settle down at the bottom of the anode. This deposition is technically called:
(A) Cathode mud
(B) Gangue
(C) Slag
(D) Anode mud

39. If one of the constituent metals in an alloy is mercury, the resulting alloy is specifically referred to as an:
(A) Emulsion
(B) Amalgam
(C) Intermetallic
(D) Isotope

40. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Plaster of Paris must be stored in a moisture-proof container.
Reason (R): Plaster of Paris rapidly absorbs moisture to form a hard solid mass of gypsum, rendering it useless.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

41. The reaction between Quicklime (CaO) and water is a classic example of which type of reaction?
(A) Endothermic and displacement
(B) Endothermic and decomposition
(C) Exothermic and double displacement
(D) Exothermic and combination

42. When Quicklime reacts completely with water, the resulting chemical compound formed is:
(A) Calcium hydroxide
(B) Calcium carbonate
(C) Calcium chloride
(D) Calcium peroxide

43. Which of the following compounds is extensively used for disinfecting drinking water to make it free of germs?
(A) Washing soda
(B) Bleaching powder
(C) Baking soda
(D) Plaster of Paris

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44. Soda-acid fire extinguishers rely on a chemical reaction to produce carbon dioxide rapidly. Which sodium compound is a key ingredient in these extinguishers?
(A) Sodium chloride compound
(B) Sodium bicarbonate
(C) Sodium carbonate decahydrate
(D) Sodium hydroxide solution

45. Match the non-metals in List I with their standard everyday applications in List II:
List I: (Non-metal)
P. Nitrogen
Q. Phosphorus
R. Sulphur
S. Graphite
List II: (Application)
1. Vulcanisation of rubber
2. Electrodes in dry cells
3. Food packaging to prevent oxidation
4. Manufacturing of matchsticks
(A) P-3, Q-4, R-1, S-2

(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

46. A small amount of gypsum is added to Portland cement clinker during its final grinding. What is the primary function of this added gypsum?
(A) To significantly increase the early mechanical strength of cement
(B) To act as a permanent decorative colouring agent in concrete
(C) To slow down the setting time of cement
(D) To substantially reduce the total overall manufacturing cost

47. In the glass manufacturing industry, the process of cooling the hot glass very slowly to relieve internal stresses and prevent cracking is called:
(A) Quenching
(B) Tempering
(C) Galvanising
(D) Annealing

48. Recycling of metals like aluminium and steel is heavily promoted in industries primarily because:
(A) Recycled metals exhibit vastly superior electrical conductivity compared to virgin metals.
(B) Recycled metals naturally develop permanent immunity against all atmospheric corrosion.
(C) It requires much less energy than extracting metals from ores.
(D) It fundamentally alters and improves the core chemical properties of the processed metals.

49. The Zawar mines situated in the Udaipur district of Rajasthan are primarily renowned for the extraction of which metal's ore?
(A) Copper
(B) Zinc
(C) Gold
(D) Iron

50. Arrange the following fundamental steps of extracting a metal from a sulphide ore in the correct sequential order:
I. Electrolytic refining
II. Concentration (enrichment) of the ore
III. Reduction of metal oxide to metal
IV. Roasting
(A) II, IV, III, I
(B) II, III, IV, I
(C) IV, II, III, I
(D) I, II, IV, III

51. Which of the following metals is known to be the most ductile, allowing a single gram of it to be drawn into a wire about 2 kilometres long?
(A) Gold
(B) Copper
(C) Silver
(D) Aluminium

52. Identify the odd one out from the following list of elements based on their classification as metalloids:
(A) Silicon
(B) Germanium
(C) Carbon
(D) Arsenic

53. If a copper coin is left in a solution of silver nitrate, the solution gradually turns blue. This confirms that:
(A) Copper is more reactive than silver.
(B) Silver is more reactive than copper.
(C) Both metals have identical reactivity.
(D) No chemical reaction has occurred.

54. Non-metals generally do not conduct electricity. However, which of the following is a good conductor of electricity?
(A) Diamond
(B) Phosphorus
(C) Sulphur
(D) Graphite

55. "Superphosphate of lime" is a well-known chemical compound extensively used in agriculture as a:
(A) Pesticide
(B) Fertiliser
(C) Fungicide
(D) Weedicide

56. What is the exact number of water molecules present as water of crystallisation in one formula unit of Washing Soda?
(A) 2
(B) 5
(C) 10
(D) 7

57. The setting of Plaster of Paris into a hard mass involves which underlying chemical process?
(A) Dehydration to form anhydrous calcium sulphate
(B) Oxidation of calcium

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(C) Decomposition into calcium oxide and sulphur dioxide
(D) Hydration to form gypsum

58. The chemical compound commonly known as "Potash Alum" is a double sulphate of potassium and which other metal?
(A) Aluminium
(B) Iron
(C) Copper
(D) Zinc

59. When washing soda crystals ($Na_2CO_3.10H_2O$) are left exposed to dry air, they lose water of crystallisation to form a white powder known as monohydrate. What is the completely anhydrous form of sodium carbonate called?
(A) Baking powder
(B) Soda ash
(C) Quicklime
(D) Slaked lime

60. Consider the following statements regarding Bleaching powder:
I. Its chemical formula is $CaOCl_2$.
II. It is soluble in cold water and leaves no unreacted residue.
III. It releases chlorine gas when it reacts with dilute acids.
Which of the above statements is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II, and III

61. Cinnabar (HgS) is a naturally occurring ore of which of the following metals?
(A) Mercury
(B) Copper
(C) Silver
(D) Lead

62. Which of the following metals is typically extracted from its oxide ore using carbon as a reducing agent?
(A) Sodium
(B) Potassium
(C) Zinc
(D) Calcium

63. Rusting is a common form of corrosion for iron. What is the generally accepted chemical formula for rust?
(A) $FeO.xH_2O$
(B) Fe_3O_4
(C) $Fe(OH)_3$
(D) $Fe_2O_3.xH_2O$

64. The process of forming a thick oxide layer of aluminium to protect it from further corrosion is formally known as:
(A) Galvanising
(B) Electroplating
(C) Anodising
(D) Alloying

65. Match the metals in List I with their most suitable extraction method in List II:
List I: (Metal)
P. Sodium
Q. Zinc
R. Gold
S. Copper (from low grade ores)
List II: (Extraction Method)
1. Reduction with carbon
2. Electrolysis of molten chloride
3. Hydrometallurgy / Leaching
4. Found in native (free) state
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-1, R-3, S-4
(D) P-3, Q-1, R-4, S-2

66. Which non-metal is an essential component used on the striking surface of a matchbox in the match industry?
(A) White phosphorus
(B) Yellow sulphur
(C) Graphite
(D) Red phosphorus

67. The process of vulcanisation improves the elasticity and strength of natural rubber by heating it with which non-metal?
(A) Sulphur
(B) Carbon
(C) Phosphorus
(D) Silicon

68. Which property of aluminium makes it the metal of choice for manufacturing thin foils used in food packaging?
(A) High density
(B) Sonority
(C) Malleability
(D) Poor thermal conductivity

69. Urea (NH_2CONH_2) is one of the most widely used nitrogenous fertilisers. Approximately what

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percentage of nitrogen by mass does pure urea contain?
(A) 46%
(B) 21%
(C) 33%
(D) 60%

70. The primary chemical constituent of standard Portland cement, making up about 60-67% of its total mass, is:
(A) Silicon dioxide (Silica)
(B) Aluminium oxide (Alumina)
(C) Magnesium oxide (Magnesia)
(D) Calcium oxide (Lime)

71. Which type of glass is specifically manufactured by alternating layers of glass and tough transparent plastic (like polyvinyl butyral) to prevent it from shattering?
(A) High-refractive flint glass
(B) Safety glass
(C) Heat-resistant Pyrex glass
(D) High-purity quartz glass

72. In the manufacturing of coloured glass, which metal compound is typically added to the molten mixture to impart a deep blue colour?
(A) Chromium salts
(B) Iron(II) salts
(C) Cobalt salts
(D) Manganese salts

73. Identify the lightest known metal from the options below, which is also heavily utilised in modern rechargeable batteries.
(A) Magnesium
(B) Aluminium
(C) Titanium
(D) Lithium

74. Baking powder is fundamentally a dry mixture of baking soda and a mild edible acid. Which acid is most commonly used for this purpose?
(A) Tartaric acid
(B) Acetic acid
(C) Hydrochloric acid
(D) Sulphuric acid

75. Match the common everyday compounds in List I with their accurate chemical formulas in List II:
List I: (Common Compound)
P. Table salt
Q. Limestone
R. Caustic soda
S. Sal ammoniac
List II: (Chemical Formula)
1. NaOH
2. NH_4Cl
3. NaCl
4. $CaCO_3$
(A) P-3, Q-1, R-4, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-2, R-3, S-4

76. Which of the following metals has an exceptionally low melting point and will start melting if kept on the palm of the hand?
(A) Lead
(B) Gallium
(C) Silver
(D) Magnesium

77. Which unreactive non-metal gas is heavily used in the food industry to flush out oxygen from potato chip packets to prevent the oil from going rancid?
(A) Nitrogen
(B) Chlorine
(C) Helium
(D) Argon

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78. Iron metal does not react with cold or hot water. Under standard conditions, it reacts only with:
(A) Ice
(B) Heavy water
(C) Steam
(D) Distilled water exclusively

79. A student tests the aqueous solution of a freshly prepared metal oxide with litmus paper. What will be the most likely observation?
(A) Blue litmus turns red
(B) Both red and blue litmus become colourless
(C) No change in the colour of either litmus paper
(D) Red litmus turns blue

80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Copper vessels develop a green coating during the rainy season.
Reason (R): Copper reacts with moist carbon dioxide in the air to form basic copper carbonate.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true

but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

81. Stainless steel is an alloy designed to resist rusting. Which element is added to iron in significant amounts (around 10-20%) to provide this rust resistance?
(A) Carbon
(B) Chromium
(C) Zinc
(D) Copper

82. "German Silver" is a prominent alloy used for making utensils and decorative items. Which of the following statements about German Silver is entirely accurate?
(A) It consists of a precise alloy containing exactly 50% pure Silver.
(B) It is a binary synthetic alloy composed of Germanium and Silver.
(C) It is a liquid-based amalgam containing elemental Mercury and Silver.
(D) It contains Copper, Zinc, and Nickel.

83. School bells are made of metals rather than non-metals because metals possess which distinct physical property?
(A) Sonority
(B) Malleability
(C) Ductility
(D) Lustre

84. Bauxite is the principal commercial ore used for the large-scale extraction of which metal?
(A) Iron
(B) Zinc
(C) Aluminium
(D) Copper

85. Which of the following sequences represents the correct arrangement of halogens (non-metals) in decreasing order of their chemical reactivity?
(A) Fluorine > Chlorine > Bromine > Iodine
(B) Iodine > Bromine > Chlorine > Fluorine
(C) Chlorine > Fluorine > Bromine > Iodine
(D) Fluorine > Bromine > Chlorine > Iodine

86. In traditional Hindi terminology, the process of galvanisation to protect iron is commonly referred to as:
(A) Tamra lepan
(B) Swarna lepan
(C) Rajat lepan
(D) Yashad lepan

87. The extremely thin edible metallic foils (varak) traditionally used to decorate Indian sweets are made from:
(A) Lead
(B) Silver
(C) Aluminium
(D) Tin

88. Metalloids play a highly critical role in the modern electronics industry because they function as:
(A) Perfect insulators
(B) Superconductors
(C) Semiconductors
(D) Electrolytes

89. Chalk, limestone, and marble are chemically diverse physical forms of the same compound. What is this compound?
(A) Calcium sulphate
(B) Calcium hydroxide
(C) Calcium bicarbonate
(D) Calcium carbonate

90. Consider the following statements regarding Sodium chloride (NaCl):
I. It is formed by the reaction of hydrochloric acid and sodium hydroxide.
II. It has a high melting point due to strong ionic bonds.
III. It conducts electricity in its solid crystalline state.
Which of the above combinations is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

91. The Froth Flotation process is primarily employed for the concentration (enrichment) of which type of ores?
(A) Oxide ores
(B) Sulphide ores
(C) Carbonate ores
(D) Halide ores

92. Which of the following compounds is the active ingredient in 'Milk of Magnesia', commonly used as an antacid to relieve stomach acidity?
(A) Magnesium chloride
(B) Magnesium hydroxide
(C) Magnesium sulphate
(D) Magnesium carbonate

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93. Hard water contains dissolved salts of calcium and magnesium. Which of the following compounds is added industrially and domestically to remove this permanent hardness?
(A) Washing soda
(B) Baking soda
(C) Bleaching powder
(D) Slaked lime

94. The chlor-alkali process is a vital industrial chemical operation. What are the three primary products yielded by this process?
(A) Sodium carbonate, Chlorine gas, Hydrogen gas
(B) Sodium chloride, Oxygen gas, Hydrogen gas
(C) Sodium hydroxide, Chlorine gas, Hydrogen gas
(D) Sodium hypochlorite, Chlorine gas, Water

95. Match the specialized alloys in List I with their respective primary metallic compositions in List II:
List I: (Specialized Alloy)
P. Duralumin
Q. Magnalium
R. Invar
S. Solder
List II: (Primary Metallic Composition)
1. Iron and Nickel
2. Lead and Tin
3. Aluminium and Copper (with Mg, Mn)
4. Aluminium and Magnesium
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-4, R-1, S-2

96. Scrap metal recycling is considered environmentally essential. Which of the following is an INCORRECT statement regarding metal recycling?
(A) It reduces greenhouse gas emissions compared to primary production.
(B) It conserves limited natural ore resources.
(C) Recycled metals inevitably lose their structural strength forever.
(D) It saves a substantial amount of electrical energy.

97. Which of the following non-metals must be stored underwater in laboratories because it ignites spontaneously when exposed to air at room temperature?
(A) Allotropic red phosphorus
(B) White phosphorus
(C) Elemental yellow sulphur
(D) Crystalline solid iodine

98. In the Rajasthan context, the regions of Bikaner and Nagaur hold vast deposits of a white crystalline mineral used in the cement industry and for making Plaster of Paris. What is this mineral?
(A) Galena
(B) Mica
(C) Bauxite
(D) Gypsum

99. Diamond and graphite display completely different physical properties despite being composed of the exact same element. Such different structural forms of the same element are termed:
(A) Allotropes
(B) Isotopes
(C) Isomers
(D) Isobars

100. Arrange the following common metals in decreasing order of their chemical reactivity (from most reactive to least reactive):
I. Iron
II. Sodium
III. Gold
IV. Zinc
(A) II, IV, I, III
(B) II, I, IV, III
(C) IV, II, I, III
(D) I, II, IV, III

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101. An alloy called Solder is universally used by electricians for welding electrical wires together. What provides solder with this specific capability?
(A) Low melting point and good electrical conductivity
(B) Extremely high melting point and poor conductivity
(C) High tensile strength and hardness
(D) Highly reactive nature at room temperature

102. Calcination is a metallurgical process where an ore is heated strongly below its melting point in the absence of air. This process is best suited for which type of ores?
(A) Concentrated sulphide ores
(B) Hydrated halide ores
(C) Pure native metallic ores

(D) Carbonate ores

103. Which of the following metals is so soft that it can be effortlessly cut with a standard kitchen knife?
(A) Iron
(B) Sodium
(C) Copper
(D) Tungsten

104. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Nitric acid (HNO_3) is rarely used to prepare hydrogen gas by reacting with metals.
Reason (R): Nitric acid is a strong oxidising agent and oxidises the hydrogen produced to water.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

105. Match the elements in List I with their characteristic properties in List II:
List I: (Element)
P. Mercury
Q. Bromine
R. Platinum
S. Lithium
List II: (Characteristic Property)
1. Lightest solid metal
2. Liquid non-metal
3. Liquid metal
4. Highly unreactive (noble) metal
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-2, R-4, S-1

106. In municipal water treatment plants, which non-metal is commonly bubbled through the filtered water to kill disease-causing bacteria?
(A) Chlorine
(B) Oxygen
(C) Nitrogen
(D) Hydrogen

107. Which non-metal is considered a primary macronutrient for plant root growth and is heavily incorporated in standard agricultural fertilisers?
(A) Iodine
(B) Phosphorus
(C) Chlorine
(D) Silicon

108. During the manufacturing of Portland cement, raw materials are heated in a rotary kiln. At approximately what temperature does the mixture fuse to form cement "clinker"?
(A) 500 °C to 600 °C
(B) 1400 °C to 1500 °C
(C) 800 °C to 900 °C
(D) 2500 °C to 3000 °C

109. Pyrex glass is extensively used for making premium laboratory glassware. What is the defining property of Pyrex glass?
(A) It is highly resistant to thermal shock.
(B) It possesses an exceptionally low optical index of refraction.
(C) It readily dissolves completely when exposed to basic solutions.
(D) It completely blocks and absorbs all incoming ultraviolet radiation.

110. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Gold and platinum are commonly found in the Earth's crust in their free (native) state.
Reason (R): Gold and platinum are placed at the bottom of the reactivity series and are highly unreactive metals.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

111. The Khetri region in Rajasthan has historical and current significance in the mining and extraction of which major metal?
(A) Aluminium
(B) Lead
(C) Gold
(D) Copper

112. The deliberate mixing of metals to form an alloy primarily helps in:
(A) Substantially decreasing the overall physical hardness of the primary metal
(B) Significantly increasing the metal's natural

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susceptibility to atmospheric corrosion
(C) Improving strength and corrosion resistance.
(D) Dramatically lowering the overall electrical resistance of the metal to zero

113. Metals like gold, silver, and platinum are collectively referred to as "noble metals" mainly because:
(A) They possess exceptionally high atomic masses and extreme physical densities.
(B) They are chemically unreactive and resist oxidation.
(C) They consistently exhibit a non-metallic dull and lustreless surface appearance.
(D) They possess crystalline structures that cannot be melted under any thermal conditions.

114. Which metal compound is extensively used in the manufacturing of sunscreens, ointments, and cosmetics due to its ability to absorb ultraviolet light?
(A) Sodium chloride
(B) Calcium sulphate
(C) Copper sulphate
(D) Zinc oxide

115. Consider the following statements about general properties of non-metals:
I. Solid non-metals are brittle and break easily upon hammering.
II. Non-metals possess low melting and boiling points compared to metals.
III. Non-metals react with dilute acids to readily displace hydrogen gas.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

116. In industrial chemistry, the term "brine" strictly refers to:
(A) A concentrated aqueous solution of sodium hydroxide
(B) A dilute aqueous solution of sulphuric acid
(C) A concentrated aqueous solution of sodium chloride
(D) Pure liquid sodium

117. Smelting is the process of extracting a metal from its roasted ore by heating it with a reducing agent in a furnace. The most universally used reducing agent in smelting is:
(A) Carbon (Coke)
(B) Elemental hydrogen gas
(C) Elemental oxygen gas
(D) Elemental sulphur powder

118. Match the important industrial processes in List I with their respective end products in List II:
List I: (Industrial Process)
P. Haber process
Q. Contact process
R. Solvay process
S. Chlor-alkali process
List II: (End Product)
1. Sulphuric acid
2. Sodium carbonate
3. Ammonia
4. Sodium hydroxide
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-1, R-2, S-4

119. What is the systematic IUPAC chemical name for the household compound 'Baking Soda'?
(A) Sodium carbonate decahydrate
(B) Sodium hydrogen carbonate
(C) Potassium carbonate
(D) Calcium hydrogen carbonate

120. Titanium is often referred to as a "strategic metal" in industries. What is the primary reason for this classification?
(A) It is categorized as the heaviest naturally occurring transition metal in the earth's crust.
(B) It exhibits extremely high radioactivity and serves as the primary fuel in nuclear reactors.
(C) It is strong, lightweight, and critical for aerospace and defence.
(D) It represents the most inexpensive and easily extracted structural metal from common ores.

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ANSWERS

1. (B) Malleability
Malleability is a characteristic physical property of metals that enables them to undergo permanent deformation under compressive stress. When metals are hammered, rolled, or beaten, their crystal structures allow atomic layers to slide past one another without breaking metallic bonds. This unique structural flexibility allows metals to form extremely thin sheets or foils without fracturing.

2. (D) Bromine
Bromine is a halogen element that naturally exists as a dense reddish-brown liquid at standard ambient temperature and pressure. While most non-metallic elements exist as gases or solid structures, bromine possesses relatively weak intermolecular forces that allow it to remain in a liquid state. It readily evaporates into a toxic vapour with a strong disagreeable odour.

3. (A) Metal oxides are basic, whereas non-metal oxides are acidic.
Oxides formed by metallic elements usually dissolve in water to produce basic solutions containing hydroxide ions, or they react with acids to yield salt and water. Conversely, non-metallic elements bond with oxygen to form acidic oxides that yield acidic solutions upon dissolving in water. This chemical distinction serves as a fundamental criterion for classifying elemental oxides.

4. (C) Zinc displacing copper from copper sulphate solution
A displacement reaction occurs when a chemically more reactive metal displaces a less reactive metal from its aqueous salt solution. In the electrochemical reactivity series, zinc is positioned above copper, indicating a higher tendency to lose electrons and form positive ions. Consequently, metallic zinc successfully displaces copper ions from copper sulphate, producing zinc sulphate and solid copper metal.

5. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Sodium is an alkali metal located near the top of the activity series, making it exceptionally reactive. Upon exposure to ambient air, sodium rapidly reacts with oxygen and atmospheric moisture in an intense exothermic reaction that generates sufficient heat to ignite liberated hydrogen gas. Storing sodium submerged in kerosene prevents any contact with oxygen and water vapour.

6. (D) Amphoteric
Metal oxides that demonstrate dual chemical behaviour by reacting with both acids and strong bases to produce salt and water are classified as amphoteric oxides. Aluminium oxide reacts with hydrochloric acid to form aluminium chloride and water, while also reacting with sodium hydroxide solution to yield sodium aluminate. Thus, aluminium oxide displays clear amphoteric properties during neutralization reactions.

7. (B) Bubbles of hydrogen gas stick to the surface of the metal.
Calcium reacts with water at room temperature in an exothermic reaction to form calcium hydroxide and evolve hydrogen gas. However, the heat evolved is insufficient to ignite the gas. As hydrogen gas bubbles evolve, they adhere to the metallic calcium surface, creating buoyancy that lifts the metal pieces and causes them to float on the water surface.

8. (C) Silicon
Metalloids are chemical elements whose physical and chemical characteristics lie intermediate between those of metals and non-metals. Silicon possesses a metallic lustre yet exhibits semiconductor electrical properties, behaving as an electrical insulator at cold temperatures while conducting electricity under specific conditions. This dual behavior places silicon squarely in the metalloid category within the periodic table.

9. (D) Roasting
In pyrometallurgical extraction, roasting is the chemical process of converting sulphide ores into metal oxides by heating the concentrated ore strongly below its melting point in the presence of excess air. This process removes sulphur in the form of volatile sulphur dioxide gas, thereby

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transforming the mineral into an oxide that can be easily reduced.

10. (B) II and III only
Minerals are naturally occurring inorganic substances containing metals found in the Earth's crust. Ores are specific minerals from which metals can be extracted conveniently and profitably on a commercial scale. Therefore, while every ore is intrinsically a mineral, not all minerals contain high enough metallic concentrations or suitable chemical compositions to qualify as ores for extraction.

11. (B) Copper and Zinc
Brass is a substitute substitution alloy composed primarily of copper and zinc, typically containing around sixty to seventy percent copper with thirty to forty percent zinc. The combination yields enhanced corrosion resistance, greater workability, improved acoustic qualities, and superior mechanical strength compared to pure copper, making it ideal for musical instruments, valves, and decorative fittings.

12. (B) $NaHCO_3$
Baking soda is chemically defined as sodium hydrogen carbonate or sodium bicarbonate, represented by the chemical formula $NaHCO_3$. It is a crystalline solid compound produced via the Solvay process that dissolves in water to form a mildly alkaline solution. When heated during cooking, it decomposes to release carbon dioxide gas, causing dough to rise.

13. (A) $CaSO_4.2H_2O$
Gypsum is a naturally occurring mineral composed of hydrated calcium sulphate, chemically expressed by the chemical formula $CaSO_4.2H_2O$. This formula indicates that two molecules of water of crystallisation are bound to every formula unit of calcium sulphate. Gypsum serves as the primary raw material for manufacturing plaster of Paris, wallboards, and agricultural soil conditioners.

14. (C) Used as an antacid in medicine
Washing soda, chemically known as sodium carbonate decahydrate, produces a strongly alkaline aqueous solution due to hydrolysis. Because of its caustic nature, it cannot be safely ingested to treat stomach hyperacidity. Mildly basic compounds like sodium bicarbonate or magnesium hydroxide are used as antacids, whereas washing soda is restricted to industrial cleansers and water softening.

15. (D) P-2, Q-1, R-4, S-3
Calcium oxide is commonly referred to as quicklime. Reaction of quicklime with water forms calcium hydroxide, which is known as slaked lime. Calcium sulphate hemihydrate corresponds to plaster of Paris due to its half-molecule water ratio per formula unit. Calcium hypochlorite is the chemical term for bleaching powder, used widely for disinfection and whitening.

16. (C) 373 K
Plaster of Paris is produced by heating gypsum at a carefully controlled temperature of 373 Kelvin or one hundred degrees Celsius. At this temperature, gypsum loses three-fourths of its hydration water to form calcium sulphate hemihydrate. Heating beyond 373 Kelvin dehydrates the salt completely into dead burnt plaster, which lacks quick setting properties.

17. (B) For the purification of muddy water
Alum, chemically identified as potassium aluminium sulphate, acts as an effective coagulant during water purification. When added to turbid or muddy water, trivalent aluminium ions neutralize negative surface charges on suspended colloidal clay particles. This causes particles to aggregate into larger flocs that rapidly settle to the bottom, leaving clear water above.

18. (D) Dry slaked lime
Bleaching powder is synthesized industrially by passing gaseous chlorine over dry slaked lime, chemically known as solid calcium hydroxide. The chemical interaction yields calcium hypochlorite along with calcium chloride and water. Maintaining dry conditions during the reaction is crucial to ensure efficient absorption and prevent excessive decomposition of the bleaching agent formed.

19. (A) Zinc
Galvanisation is an anti-corrosion technique that involves applying a protective coating of molten zinc onto iron or steel surfaces. Zinc acts as both a physical barrier and a sacrificial anode because zinc is more electrochemically reactive than iron. Even if the zinc layer is scratched, it oxidises preferentially, preserving the underlying iron metal.

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20. (A) Potassium > Sodium > Calcium > Magnesium
The reactivity series ranks metals based on their relative standard electrode potentials and ease of losing valence electrons. Potassium is the most reactive alkali metal among the choices, followed by sodium. Calcium belongs to group two and is less reactive than sodium, while magnesium is less reactive than calcium due to its higher ionization energy.

21. (A) Iodine
Tincture of iodine is a medical antiseptic solution typically comprising two to seven percent elemental iodine alongside potassium iodide dissolved in an aqueous ethanol mixture. When applied to minor cuts or skin wounds, elemental iodine acts as a broad-spectrum antimicrobial agent, rapidly destroying harmful bacteria, fungi, and viruses to prevent localized wound infections.

22. (D) Nitrogen, Phosphorus, Potassium
In agricultural chemistry, NPK stands for Nitrogen, Phosphorus, and Potassium, which represent the three primary macronutrients required for healthy plant growth and development. Nitrogen promotes foliage growth, phosphorus supports root establishment and flowering, while potassium enhances disease resistance and regulates water movement within plant tissues. Commercial fertilisers specify ratios based on these essential elements.

23. (B) Limestone
Limestone, which is chemically comprised of calcium carbonate, serves as the predominant raw material in manufacturing Portland cement. During cement production, limestone is crushed and burned alongside clay in high-temperature kilns. Thermal decomposition transforms calcium carbonate into calcium oxide, which reacts with silica and alumina to yield the essential hydraulic binding compounds.

24. (C) Silica
Silica, or silicon dioxide, functions as the fundamental network former in glass manufacturing. When silica sand is melted at elevated temperatures and subsequently cooled rapidly, it forms an amorphous solid matrix without crystallizing. Modifiers like sodium carbonate and fluxing oxides are added to lower the melting temperature and tailor the physical stability.

25. (D) P-2, Q-3, R-4, S-1
Bauxite is the primary ore used to extract aluminium through electrolytic reduction. Haematite is a major oxide ore of iron processed in blast furnaces. Calamine, containing zinc carbonate, serves as a prominent zinc ore. Cinnabar consists of mercury sulphide and represents the principal commercial source for extracting metallic mercury from mineral deposits.

26. (A) Philosopher's wool
Zinc oxide is historically termed philosopher's wool due to its fluffy white aesthetic appearance when zinc metal is burned in ambient air. Alchemists collected these lightweight crystalline filaments during early combustion experiments. Zinc oxide is an amphoteric compound widely applied in vulcanizing rubber, formulating protective skin ointments, manufacturing pigments, and producing sunscreens.

NODIA

27. (B) Chlor-alkali process
The industrial electrolysis of concentrated aqueous sodium chloride solution, commonly known as brine, is called the chlor-alkali process. During electrolysis, pure chlorine gas is evolved at the anode while hydrogen gas is produced at the cathode. Sodium hydroxide solution remains in the cell, providing three essential basic industrial chemical commodities simultaneously.

28. (B) Silver sulphide
Silver articles tarnish and turn black when exposed to atmospheric air due to slow chemical reaction with trace amounts of hydrogen sulphide gas present in the environment. This atmospheric oxidation leads to the formation of a thin, protective surface layer of black silver sulphide, which alters the reflective metallic appearance of the silver object.

29. (A) Copper hydroxide and Copper carbonate
When copper metal is exposed to moist atmospheric air containing carbon dioxide, oxygen, and water vapour over prolonged periods, it undergoes slow corrosion. This chemical reaction produces a characteristic green surface coating composed of basic copper carbonate, which is a structural mixture of

copper hydroxide and copper carbonate that shields underlying metal.

30. (D) I, II, and III
Bronze is an alloy formulated from copper and tin. Solder is an alloy of lead and tin utilized for joining electrical circuits due to its low melting point. Stainless steel contains iron alloyed with chromium, nickel, and carbon, imparting exceptional corrosion resistance and high mechanical strength suitable for industrial applications.

31. (D) Silver
Silver exhibits the highest electrical conductivity of all metals at room temperature due to its crystal structure and high density of free valence electrons. Its extremely low electrical resistivity allows electric current to flow with minimal opposition, surpassing copper and gold, although economic cost limits its widespread use in large power distribution networks.

32. (C) Iodine
Non-metals are typically dull in surface appearance and lack natural metallic lustre. Iodine represents a notable exception among non-metallic elements because its crystalline solid state features shiny, deep violet-black crystals that exhibit a distinct metallic sheen. This lustrous property arises from electron delocalization within its crystalline lattice, reflecting visible light efficiently.

33. (B) Diamond
Diamond is a crystalline allotrope of carbon in which each carbon atom is covalently bonded to four neighbouring carbon atoms in a rigid three-dimensional tetrahedral lattice. This intense covalent network structure imparts supreme hardness, making diamond the hardest naturally occurring substance known to science, widely used in industrial cutting tools and abrasives.

34. (D) It burns with a characteristic pop sound.
When reactive metals displace hydrogen from dilute strong acids, colorless and odorless hydrogen gas is generated. The standard confirmation test involves bringing a burning wooden splint near the mouth of the reaction tube. Hydrogen gas undergoes rapid combustible reaction with atmospheric oxygen, producing a small controlled explosion accompanied by a distinct pop sound.

35. (A) It is a strong oxidising agent that oxidises hydrogen to water.
Dilute nitric acid acts as a powerful oxidising agent in aqueous reactions. When metals react with nitric acid, any nascent hydrogen gas initially formed is immediately oxidised by the acid to form water. Simultaneously, the nitric acid undergoes reduction to yield various nitrogen oxides such as nitric oxide or nitrogen dioxide.

36. (C) 3 : 1
Aqua regia is a freshly prepared corrosive chemical mixture composed of concentrated hydrochloric acid and concentrated nitric acid mixed in a precise volume ratio of three to one. The combined action generates volatile nitrosyl chloride and reactive free chlorine, allowing aqua regia to dissolve noble metals like gold and platinum successfully.

37. (A) Thermite reaction
The thermite reaction involves the exothermic reduction of iron oxide using aluminium powder as a reducing agent. Because aluminium has a higher affinity for oxygen than iron, it displaces iron, generating molten iron along with aluminium oxide. The immense thermal energy released melts the produced iron, making it effective for welding railway tracks.

38. (D) Anode mud
During the electrolytic refining of copper, an impure copper slab serves as the anode while pure copper acts as the cathode in a copper sulphate bath. As electric current flows, copper dissolves from the anode. Insoluble noble impurities like gold, silver, and platinum fall off and settle below the anode as anode mud.

39. (B) Amalgam
An amalgam is a specialized alloy formed by combining elemental mercury with one or more other metals such as silver, tin, gold, or sodium. Because mercury is liquid at room temperature, it readily dissolves or alloys with these metals to form solid or semi-solid metallic solutions widely used in dental fillings and chemical reductions.

40. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Plaster of Paris, chemically calcium sulphate hemihydrate, possesses a high affinity for ambient moisture. When exposed to water or

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atmospheric humidity, it undergoes a hydration reaction, reabsorbing water of crystallisation to reform hard crystalline gypsum. To prevent this premature hardening and loss of usability, plaster of Paris must be stored in moisture-proof containers.

41. (D) Exothermic and combination
When quicklime reacts vigorously with water, solid calcium oxide combines with liquid water to form a single chemical product, slaked lime. Because two reactants combine into one product, it represents a combination reaction. The reaction releases significant thermal energy, boiling the water and classifying it as an exothermic chemical process.

42. (A) Calcium hydroxide
Quicklime, chemically known as calcium oxide, undergoes an exothermic slaking reaction upon mixing with water to form calcium hydroxide. Calcium hydroxide is an inorganic compound that dissolves sparingly in water to yield an alkaline solution called lime water. It is extensively employed in whitewashing walls, soil stabilization, and industrial neutralization.

43. (B) Bleaching powder
Bleaching powder, chemically named calcium hypochlorite, releases active free chlorine when dissolved in aqueous water environments. Chlorine acts as a powerful chemical disinfectant by oxidizing vital cellular structures and metabolic enzymes within pathogenic microorganisms, thereby rendering municipal drinking water safe from dangerous waterborne bacteria, viruses, and disease-causing microbial pathogens.

44. (B) Sodium bicarbonate
Soda-acid fire extinguishers contain a solution of sodium bicarbonate alongside a glass ampoule filled with concentrated sulphuric acid. When activated, the acid mixes with sodium bicarbonate, triggering a rapid neutralization reaction that evolves copious volumes of carbon dioxide gas. The generated gas displaces atmospheric oxygen around flames, effectively extinguishing fire.

45. (A) P-3, Q-4, R-1, S-2
Nitrogen gas provides an unreactive inert atmosphere in snack packaging to prevent fat oxidation and rancidity. Red phosphorus is coated on matchbox striking surfaces to initiate friction combustion. Sulphur is added during rubber vulcanisation to create molecular cross-links, while graphite conducts electricity efficiently as conductive electrodes in dry battery cells.

46. (C) To slow down the setting time of cement
During industrial cement manufacturing, a small percentage of gypsum is interground with clinker to control the hydration rate of tricalcium aluminate. Without gypsum, cement sets almost instantaneously upon mixing with water, preventing adequate handling and placement. Gypsum retards this initial flash setting process, ensuring sufficient practical working time for concrete applications.

47. (D) Annealing
Annealing is a thermal treatment process in glass manufacturing where freshly formed glass articles are slowly cooled inside a controlled temperature kiln called a lehr. Controlled cooling minimizes thermal gradients across the glass structure, preventing the formation of localized internal mechanical stresses that would otherwise cause spontaneous cracking or shattering.

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48. (C) It requires much less energy than extracting metals from ores.
Extracting primary metals directly from natural ores requires energy-intensive mining, crushing, roasting, and high-temperature electrolytic or chemical reduction. In contrast, recycling scrap metal bypasses raw ore refining steps, consuming up to ninety-five percent less electrical and thermal energy. Consequently, recycling conserves limited fossil energy resources while reducing greenhouse gas emissions significantly.

49. (B) Zinc
The Zawar mining region located in Udaipur district, Rajasthan, is historically and commercially renowned for containing extensive zinc and lead ore deposits. The primary mineral mined at Zawar is sphalerite, a zinc sulphide mineral, alongside calamine. Mining operations here supply essential raw zinc ore for domestic smelting and refining industries.

50. (A) II, IV, III, I
Extracting metal from a sulphide ore begins with froth flotation to concentrate the mineral gangue. Next, roasting converts the concentrated sulphide ore into metal oxide in excess air. Chemical reduction then transforms the metal

oxide into crude metal using carbon. Finally, electrolytic refining purifies the crude metal to obtain high-purity element.

51. (A) Gold
Gold is recognized as the most ductile of all chemical elements. Ductility describes the mechanical capability of a solid material to undergo extensive plastic deformation under tensile stress without fracturing. One single gram of pure metallic gold can be drawn into a microscopic continuous wire measuring approximately two kilometres in length.

52. (C) Carbon
Carbon is categorized strictly as a typical non-metal element belonging to group fourteen of the periodic table, whereas silicon, germanium, and arsenic are classified as metalloids. Metalloids possess physical and electrical properties intermediate between metals and non-metals, while carbon forms covalent organic molecules and non-metallic allotropes like graphite and diamond.

53. (A) Copper is more reactive than silver.
When a metallic copper coin is immersed in aqueous silver nitrate, a displacement reaction occurs because copper is located above silver in the reactivity series. Copper oxidises by losing electrons to form copper ions in solution, turning the liquid blue. Concurrently, silver ions gain electrons, precipitating as solid metallic silver.

54. (D) Graphite
Graphite is a crystalline allotrope of carbon featuring hexagonal planar layers of carbon atoms. Within each sheet, each carbon atom forms covalent bonds with three adjacent carbon atoms, leaving one delocalized electron per atom. These delocalized valence electrons move freely across the planar sheets, making graphite an exceptional conductor of electricity.

55. (B) Fertiliser
Superphosphate of lime is an inorganic chemical compound synthesized by treating insoluble rock phosphate with concentrated sulphuric acid. The reaction yields water-soluble monocalcium phosphate alongside calcium sulphate. Farmers apply this compound to agricultural soils as a phosphatic fertiliser to supply readily accessible phosphorus required for root growth and crop yield.

56. (C) 10
Washing soda is chemically defined as hydrated sodium carbonate decahydrate, represented by the chemical formula $Na_2CO_3.10H_2O$. Each formula unit of sodium carbonate contains exactly ten molecules of water of crystallisation locked within its crystalline lattice, imparting structure and stability to the solid hydrated salt crystals under standard room temperature.

57. (D) Hydration to form gypsum
When plaster of Paris, which is calcium sulphate hemihydrate, is mixed with liquid water, it undergoes an exothermic hydration reaction. The compound absorbs water to re-form interlocking needle-like crystals of dihydrated calcium sulphate, commonly known as gypsum. This crystal growth creates a rigid, solid mass that sets firmly within minutes.

58. (A) Aluminium
Potash alum is a hydrated double salt chemically designated as potassium aluminium sulphate decahydrate. Its crystal structure contains both monovalent potassium ions and trivalent aluminium ions bound alongside sulphate anions and water of crystallisation. The trivalent aluminium content makes potash alum an effective coagulant for municipal water purification and styptic treatments.

59. (B) Soda ash
Washing soda crystals lose nine molecules of hydration water upon exposure to dry ambient air through efflorescence, forming sodium carbonate monohydrate. When heated strongly above one hundred degrees Celsius, the remaining water is expelled completely, leaving purely anhydrous sodium carbonate, which is commercially known as soda ash.

60. (B) I and III only
Bleaching powder has the correct chemical formula $CaOCl_2$. When treated with dilute acids, it undergoes decomposition to release gaseous chlorine, which provides its active bleaching action. However, bleaching powder is only sparingly soluble in water, leaving behind an insoluble milky residue composed of unreacted calcium hydroxide and insoluble impurities.

61. (A) Mercury
Cinnabar is the principal mineralogical name for mercury(II) sulphide, represented by the

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chemical formula HgS. It represents the primary natural ore source used globally for extracting pure metallic mercury. Heating cinnabar in air oxidises the sulphide to sulphur dioxide, yielding mercury vapour that condensates into liquid mercury metal.

62. (C) Zinc
Zinc occupies a middle position in the electrochemical reactivity series. Zinc oxide is moderately stable and can be economically reduced to elemental zinc metal by heating with carbon in the form of coke at high temperatures, yielding zinc vapour and carbon monoxide gas. Highly reactive metals require electrolytic reduction instead.

63. (D) $Fe_2O_3.xH_2O$
Rusting is an electrochemical corrosion process occurring when iron metal is exposed simultaneously to oxygen and moisture. The iron oxidises to form hydrated ferric oxide, represented chemical formula $Fe_2O_3.xH_2O$, where x represents a variable number of water molecules. Rust forms a reddish-brown, flaky layer that continuously spalls off, exposing fresh metal.

64. (C) Anodising
Anodising is an electrolytic coating process used to thicken the natural protective aluminium oxide film on aluminium objects. The aluminium part acts as the anode in an aqueous sulphuric acid bath. Oxygen liberated at the anode reacts with aluminium surface atoms, forming a durable, corrosion-resistant, and non-porous aluminium oxide coating.

65. (B) P-2, Q-1, R-4, S-3
Highly reactive sodium metal is extracted via molten salt electrolysis. Medium reactivity zinc oxide is reduced using carbon heating. Noble gold is found naturally uncombined in its native state due to low chemical affinity. Low-grade copper ores are extracted through hydrometallurgical leaching processes using dilute acids and bacterial action.

66. (D) Red phosphorus
Red phosphorus is a stable, non-toxic allotrope of elemental phosphorus used on the striking surfaces of safety matchboxes. Mixed with powdered glass and binders, red phosphorus converts into volatile white phosphorus due to frictional heat when a match is struck, igniting the combustible sulfur and potassium chlorate head safely.

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67. (A) Sulphur
Natural rubber consists of polyisoprene polymers that are soft and sticky when warm. Vulcanisation is a chemical industrial process involving heating raw rubber with elemental sulphur. Sulphur atoms establish covalent cross-links between adjacent polymer chains, enhancing structural elasticity, tensile strength, thermal stability, and resistance to chemical degradation significantly.

68. (C) Malleability
High malleability allows aluminium metal to be easily rolled into micro-thin flexible foils without cracking or tearing. Aluminium foils act as highly effective barriers against atmospheric moisture, light, oxygen, and microorganisms, protecting food products from spoilage. Its combination of high malleability, non-toxicity, and light weight makes aluminium ideal for food packaging.

69. (A) 46%
Pure urea is an organic compound with the chemical formula NH_2CONH_2 and a molecular mass of sixty atomic mass units. Each molecule contains two nitrogen atoms contributing twenty-eight atomic mass units. Calculating the mass percentage of nitrogen yields approximately forty-six percent, making urea the most concentrated solid nitrogenous fertiliser available.

70. (D) Calcium oxide (Lime)
Calcium oxide, commonly known as lime, forms sixty to sixty-seven percent of Portland cement by total weight. Derived from heating limestone, calcium oxide combines with silicates, aluminates, and ferrites during calcination to form essential hydraulic binding compounds. Proper lime concentration ensures strength, though excess lime causes unsoundness and cracking in concrete.

71. (B) Safety glass
Safety glass, also known as laminated glass, is produced by sandwiching a tough, transparent interlayer of polyvinyl butyral plastic between two or more glass sheets under heat and pressure. When impacted, the plastic interlayer retains broken glass fragments, preventing sharp shards from detaching and significantly reducing risk of severe mechanical injury.

72. (C) Cobalt salts
Cobalt compounds, such as cobalt oxide or cobalt carbonate, are highly potent colouring agents in glassmaking. When added in minor quantities to molten glass, cobalt ions integrate into the silicate network, absorbing red and yellow wavelengths of visible light while transmitting deep blue light, producing rich cobalt blue colored glass.

73. (D) Lithium
Lithium is the lightest metallic element and least dense solid metal, with a density roughly half that of liquid water. Belonging to alkali metals, lithium exhibits high electrochemical potential and superior energy density, making it essential in rechargeable lithium-ion batteries powering modern electronic devices, electric vehicles, and renewable energy storage systems.

74. (A) Tartaric acid
Baking powder is a dry chemical leavening formulation containing sodium bicarbonate and a mild solid organic acid like tartaric acid. When moistened in dough, tartaric acid reacts with sodium bicarbonate, generating carbon dioxide gas bubbles that expand during baking, neutralizing bitter sodium carbonate and creating a light, porous texture.

75. (B) P-3, Q-4, R-1, S-2
Table salt corresponds to sodium chloride. Limestone is composed of calcium carbonate, forming natural sedimentary rock structures. Caustic soda is the common name for sodium hydroxide, an important industrial base. Sal ammoniac refers to ammonium chloride, an inorganic salt historically used in soldering fluxes, dry cells, and textile printing.

76. (B) Gallium
Gallium is a post-transition metal possessing an unusually low melting point of 29.76 degrees Celsius. Because human body temperature averages thirty-seven degrees Celsius, holding a solid sample of metallic gallium in the palm transfers thermal energy, causing the metal to melt into a liquid mirror-like pool without causing chemical skin burns.

77. (A) Nitrogen
Diatomic nitrogen is an odorless, non-toxic, and chemically unreactive inert gas at ambient temperatures. Food manufacturers use modified atmosphere packaging by flushing sealed chip bags with pure nitrogen gas. Displacing oxygen gas suppresses lipid oxidation and rancidity of oils while inflating the package to cushion delicate snack chips during transport.

78. (C) Steam
Metallic iron exhibits low chemical reactivity with water and does not react with cold or hot liquid water. However, when red-hot iron metal is exposed to gaseous water vapour, or steam, a vigorous redox reaction occurs to produce ferrosoferric oxide, chemically expressed as Fe_3O_4, and liberate hydrogen gas continuously.

79. (D) Red litmus turns blue
Metallic oxides are basic anhydrides that react with water to form basic metal hydroxide solutions. Dissolving a metal oxide in water yields hydroxyl ions, creating an alkaline medium. Testing this basic solution with acid-base indicators causes red litmus paper to change colour to blue, confirming the basic nature of the dissolved oxide.

80. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
During rainy seasons, elevated atmospheric humidity combined with dissolved carbon dioxide and oxygen promotes the slow corrosion of copper vessels. Copper oxidises to form basic copper carbonate, a greenish chemical mixture of copper hydroxide and copper carbonate. This patina layer adheres to the metal surface, giving copper its characteristic green appearance.

81. (B) Chromium
Stainless steel is an alloy composed of iron, carbon, and at least ten to twenty percent chromium. Chromium reacts with atmospheric oxygen to form an invisible, self-healing oxide film of chromium oxide on the surface. This passive layer prevents moisture and oxygen from reaching underlying iron, granting excellent rust resistance.

82. (D) It contains Copper, Zinc, and Nickel.
German silver, also known as nickel silver, is a non-ferrous alloy typically composed of approximately fifty percent copper, thirty percent zinc, and twenty percent nickel. Despite its deceptive common name, German silver contains no elemental silver. The addition of nickel provides a lustrous silvery-white metallic

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appearance, corrosion resistance, and structural strength.

83. (A) Sonority
Sonority is the physical property of metals to emit a deep, ringing sound when struck by a hard object. Metallic bonds allow acoustic vibration waves to propagate through the crystalline lattice with low damping. Non-metals lack this structural property and absorb vibrational energy, making metals uniquely suited for manufacturing bells and gongs.

84. (C) Aluminium
Bauxite is a sedimentary rock that serves as the principal commercial ore for aluminium extraction. Consisting primarily of hydrated aluminium oxides like gibbsite and boehmite mixed with iron oxides, bauxite is refined via the Bayer process to extract pure alumina, which subsequently undergoes Hall-Héroult molten salt electrolysis to yield metallic aluminium.

85. (A) Fluorine > Chlorine > Bromine > Iodine
Chemical reactivity among group seventeen halogens decreases down the column as atomic radius increases and electronegativity diminishes. Fluorine possesses the smallest atomic radius and highest electron affinity, making it the most reactive halogen element. Reactivity sequentially decreases from fluorine to chlorine, then to liquid bromine, and finally to crystalline iodine.

86. (D) Yashad lepan
In Hindi chemical terminology, galvanisation is termed Yashad lepan, where Yashad refers to elemental zinc and lepan denotes coating or plating. The technique involves applying a thin protective coating of zinc onto iron or steel articles to prevent rusting through physical barrier protection and sacrificial anodic action in moist environments.

87. (B) Silver
Varak is an edible ultra-thin foil crafted by hammering high-purity silver metal between leather sheets. Due to extreme malleability, silver can be pounded into microscopic leaves only a few micrometres thick. Silver foil is chemically unreactive, non-toxic, and anti-bacterial, widely used as an aesthetic decorative topping on traditional Indian confectionery.

88. (C) Semiconductors
Metalloids like silicon and germanium possess intermediate electrical conductivity that increases with temperature or controlled chemical doping. Unlike metallic conductors or non-metallic insulators, these semiconductor materials allow precise regulation of electron flow, forming the essential foundation for fabricating microchips, transistors, diodes, solar cells, and modern integrated electronic circuits.

89. (D) Calcium carbonate
Chalk, limestone, and marble are distinct mineralogical polymorphs of calcium carbonate, represented by the chemical formula $CaCO_3$. Chalk is a soft, porous sedimentary rock formed from microscopic marine shells. Limestone is a denser sedimentary rock, while marble represents a hard metamorphic rock formed when limestone undergoes extreme heat and pressure underground.

90. (A) I and II only
Sodium chloride is formed through the neutralization of hydrochloric acid with sodium hydroxide. High lattice energy from ionic electrostatic attraction gives sodium chloride a high melting point. In solid crystalline form, sodium and chloride ions are immobilized within the crystal lattice, preventing electrical conduction until melted or dissolved in water.

91. (B) Sulphide ores
Froth flotation is a metallurgical beneficiation method tailored for hydrophobic sulphide ores such as zinc blende, galena, and copper pyrites. Finely ground ore is mixed with water, pine oil, and xanthates. Sulphide ore particles selectively adhere to oil bubbles and float to the surface as froth, while hydrophilic gangue sinks.

92. (B) Magnesium hydroxide
Milk of magnesia is an aqueous liquid suspension of magnesium hydroxide in pure water. Magnesium hydroxide is a mild, non-corrosive basic compound. When ingested, it neutralizes excessive hydrochloric acid secreted in the stomach to form magnesium chloride and water, relieving heartburn, acid indigestion, and stomach upset without damaging gastrointestinal mucosa.

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93. (A) Washing soda
Permanent water hardness is caused by dissolved sulphate and chloride salts of calcium and magnesium. Adding washing soda, or sodium carbonate, precipitates these soluble calcium and magnesium ions as insoluble carbonates. Removing these divalent cation ions softens the water, allowing soap to lather effectively without forming insoluble curd or scum.

94. (C) Sodium hydroxide, Chlorine gas, Hydrogen gas
The chlor-alkali process electrolyses concentrated sodium chloride brine solution. The electrolytic reaction drives the simultaneous formation of three major industrial chemical compounds: gaseous chlorine liberated at the anode, gaseous hydrogen liberated at the cathode, and sodium hydroxide accumulated in the remaining aqueous electrolyte, serving paper, soap, and chemical manufacturing.

95. (D) P-3, Q-4, R-1, S-2
Duralumin is a strong aluminium alloy containing copper, manganese, and magnesium, widely used in aircraft components. Magnalium contains aluminium alloyed with magnesium, providing light weight and corrosion resistance. Invar consists of iron and nickel, exhibiting an exceptionally low thermal expansion coefficient. Solder is a fusible alloy of lead and tin.

96. (C) Recycled metals inevitably lose their structural strength forever.
Metallic recycling melts scrap metal to re-solidify purified element without altering atomic bonding or lattice structures. Consequently, recycled metals retain their original mechanical strength, conductivity, and durability indefinitely. Claims that recycled metals suffer permanent loss of structural integrity are scientifically incorrect, making metallic elements infinitely recyclable without physical degradation.

97. (B) White phosphorus
White phosphorus is an extremely reactive, translucent allotrope of phosphorus consisting of tetrahedral P4 molecules with high ring strain. Due to low ignition temperature and high reactivity, white phosphorus spontaneously ignites in air to form phosphorus pentoxide. Submerging white phosphorus in water prevents exposure to atmospheric oxygen, ensuring safe storage.

98. (D) Gypsum
Gypsum is a soft, hydrated calcium sulphate mineral abundant in Bikaner, Nagaur, and Barmer districts of Rajasthan. Rajasthan accounts for over ninety percent of India's total gypsum production. Extracted gypsum serves as an essential raw material in manufacturing Portland cement, soil reclamation, and thermal processing into plaster of Paris.

99. (A) Allotropes
Allotropes are distinct structural forms of the same chemical element existing in the same physical state. Although diamond and graphite consist entirely of carbon atoms, differing covalent bonding arrangements yield contrasting physical properties. Diamond forms a rigid three-dimensional tetrahedral lattice, whereas graphite features weak Van der Waals forces between planar hexagonal layers.

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100. (A) II, IV, I, III
Reactivity of metals decreases in accordance with their position in the activity series. Sodium is an alkali metal located at the top of the reactivity series, making it the most reactive. Zinc follows sodium, while iron is less reactive than zinc. Gold is positioned near the bottom, exhibiting inert noble character.

101. (A) Low melting point and good electrical conductivity
Solder is a binary alloy composed of lead and tin, engineered specifically to exhibit a low melting point between 180 and 200 degrees Celsius. Its low melting threshold allows electricians to melt it easily using a soldering iron, while its metallic character provides good electrical conductivity for joining electrical circuits.

102. (D) Carbonate ores
Calcination involves heating solid mineral ores strongly below their melting temperature in the absence or limited supply of air. This thermal decomposition method is suited for carbonate and hydrated ores, expelling carbon dioxide gas and bound water of crystallisation to yield a porous metal oxide suitable for subsequent chemical reduction.

103. (B) Sodium
Sodium is an alkali metal possessing a soft physical consistency due to its body-centered cubic crystal lattice and single valence electron

per atom, which results in relatively weak metallic bonding. Consequently, solid sodium exhibits low shear strength and hardness, allowing it to be cut easily with a standard knife like soft wax.

104. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Nitric acid is rarely used to generate elemental hydrogen gas through reactions with metals. Because nitric acid acts as a powerful oxidising agent, any hydrogen gas produced during initial displacement is immediately oxidised into water. Concurrently, nitric acid undergoes reduction to generate nitrogen oxides such as nitric oxide or nitrogen dioxide.

105. (D) P-3, Q-2, R-4, S-1
Mercury is the only metallic element naturally existing as a liquid at room temperature. Bromine is a liquid halogen non-metal. Platinum is placed at the bottom of the reactivity series as an unreactive noble metal. Lithium is an alkali metal recognized as the lightest solid metallic element in existence today.

106. (A) Chlorine
Elemental chlorine gas is dissolved in water during municipal water treatment processes to achieve disinfection. Chlorine acts as a potent oxidising agent, generating hypochlorous acid in aqueous solution. Hypochlorous acid penetrates bacterial cell walls, disrupting vital metabolic enzymes and cellular structures, thereby effectively eliminating pathogenic bacteria and waterborne microbes.

107. (B) Phosphorus
Phosphorus is an essential non-metallic macronutrient required by growing plants for cell division, energy transfer via adenosine triphosphate, nucleic acid synthesis, and robust root development. Agricultural soils are enriched with phosphatic fertilisers like superphosphate to compensate for natural phosphorus deficiencies and improve overall crop development and root establishment.

108. (B) 1400 °C to 1500 °C
In Portland cement manufacturing, pulverized limestone and clay are fed into an inclined rotary kiln heated to peak temperatures between 1400 and 1500 degrees Celsius. At these extreme thermal conditions, raw oxides undergo partial fusion, reacting to form nodular fused masses termed cement clinker containing calcium silicates and aluminates.

109. (A) It is highly resistant to thermal shock.
Pyrex glass is a borosilicate glass formulation containing silica and boron trioxide. Incorporating boron trioxide significantly reduces the material's coefficient of thermal expansion compared to soda-lime glass. Consequently, Pyrex glass expands minimally when heated, rendering it highly resistant to thermal shock, internal thermal stress, and cracking during abrupt temperature changes.

110. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Gold and platinum occupy positions at the extreme bottom of the electrochemical activity series. Possessing high ionization energies and low chemical affinity for oxygen, moisture, and carbon dioxide, these noble metals resist atmospheric oxidation under normal geological conditions. Consequently, they remain found in their native metallic state within the Earth's crust.

111. (D) Copper
The Khetri belt located in Jhunjhunu district, Rajasthan, is an ancient and prominent copper mining hub managed by Hindustan Copper Limited. The region features chalcopyrite and copper sulphide deposits. Mining and smelting facilities at Khetri extract and refine raw ore to yield high-purity refined copper metal for domestic electrical industries.

112. (C) Improving strength and corrosion resistance.
Alloying involves combining a primary metal with other metals or non-metals to form a homogeneous mixture. Alloying modifies internal crystal lattices, disrupting atomic sliding under stress. This structural modification enhances mechanical hardness, tensile strength, wear resistance, and resistance to atmospheric corrosion, while lowering melting points to suit specific engineering applications.

113. (B) They are chemically unreactive and resist oxidation.
Gold, silver, and platinum are designated as noble metals due to their chemical inertness and high resistance to oxidation and corrosion. Positioned at the bottom of the reactivity series, these metals do not readily react with oxygen, water,

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or common acids under ambient conditions, retaining their metallic shine over centuries.

114. (D) Zinc oxide
Zinc oxide is a physical inorganic broad-spectrum ultraviolet filter that efficiently absorbs and scatters ultraviolet-A and ultraviolet-B radiation. Because of its wide bandgap and non-irritating properties on human skin, zinc oxide is widely formulated into topical sunscreens, protective skin ointments, calamine lotions, and cosmetic products to prevent sun damage.

115. (A) I and II only
Solid non-metals are brittle and break easily into pieces under mechanical stress without exhibiting malleability. Non-metals generally possess low melting and boiling points due to weak intermolecular attraction forces. Unlike metals, non-metals do not displace hydrogen gas from dilute acids because non-metals cannot donate electrons to reduce hydrogen ions.

116. (C) A concentrated aqueous solution of sodium chloride
In industrial chemical operations, brine denotes a highly concentrated aqueous solution of sodium chloride, typically containing around twenty-six percent dissolved salt by weight. Brine serves as the foundational feedstock in the chlor-alkali process to manufacture chlorine gas, hydrogen gas, and sodium hydroxide, as well as in Solvay sodium carbonate synthesis.

117. (A) Carbon (Coke)
Smelting is a pyrometallurgical thermal process used to reduce roasted metal oxides to free molten metal. Carbon, in the form of metallurgical coke, is the primary chemical reducing agent because of its cheap availability and high thermodynamic affinity for oxygen at elevated temperatures, forming carbon monoxide and releasing free metal.

118. (D) P-3, Q-1, R-2, S-4
The Haber process synthesizes ammonia gas from atmospheric nitrogen and hydrogen. The Contact process oxidises sulphur dioxide to produce concentrated sulphuric acid. The Solvay process utilizes ammonia and brine to yield sodium carbonate. The Chlor-alkali process electrolyses aqueous sodium chloride to produce sodium hydroxide alongside chlorine and hydrogen gases.

119. (B) Sodium hydrogen carbonate
Baking soda is the household common name for the pure inorganic chemical compound whose systematic IUPAC name is sodium hydrogen carbonate, or sodium bicarbonate. Represented by the chemical formula $NaHCO_3$, this crystalline salt consists of sodium cations and hydrogen carbonate anions, acting as a mild base and dry leavening agent.

120. (C) It is strong, lightweight, and critical for aerospace and defence.
Titanium is classified as a strategic metal due to its high strength-to-weight ratio, exceptional resistance to corrosion, and ability to withstand extreme temperatures. These characteristics make titanium indispensable in defence, military armor, aerospace engineering, jet engine components, spacecraft hulls, and medical implants where structural reliability under severe conditions is paramount.

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CHAPTER 03
Carbon and Hydrocarbons

1. What is the atomic number of carbon?
(A) 4
(B) 6
(C) 8
(D) 12

2. What is the valency of carbon in its organic compounds?
(A) 2
(B) 3
(C) 4
(D) 6

3. The unique property of carbon atoms to form bonds with other carbon atoms, giving rise to large molecules, is called:
(A) Catenation
(B) Isomerism
(C) Allotropy
(D) Polymerization

4. What type of chemical bond is predominantly formed by carbon to satisfy its tetravalency?
(A) Ionic bond
(B) Hydrogen bond
(C) Covalent bond
(D) Metallic bond

5. Which of the following is a general characteristic of organic compounds compared to inorganic compounds?
(A) Low melting and boiling points
(B) High melting and boiling points
(C) High electrical conductivity in solid state
(D) Formation of strong ionic bonds

6. What is the general formula for saturated open-chain hydrocarbons (alkanes)?
(A) CnH_{2n}
(B) CnH_{2n-2}
(C) CnH_{2n+1}
(D) CnH_{2n+2}

7. Match the hydrocarbon series in List I with its correct example in List II.
List I: (Hydrocarbon Series)
P. Alkane
Q. Alkene
R. Alkyne
S. Aromatic
List II: (Example)
1. Ethene
2. Ethyne
3. Benzene
4. Ethane
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-1, S-2

8. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Carbon predominantly forms covalent bonds rather than ionic bonds.
Reason (R): Carbon has four valence electrons and requires a very large amount of energy to either lose or gain four electrons to form stable ions.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

9. Saturated hydrocarbons generally burn in the air with which type of flame?
(A) Yellow, sooty flame
(B) Green flame
(C) Red flame
(D) Clean blue flame

10. Unsaturated hydrocarbons are characterized by the presence of:
(A) Carbon-carbon double or triple bonds
(B) Carbon-carbon single bonds exclusively
(C) Fully closed saturated ring structures
(D) Intermolecular hydrogen bonds

11. What is the general formula for alkenes?
(A) CnH_{2n+2}
(B) CnH_{2n}

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(C) CnH_{2n-2}
(D) CnH_{2n-4}

12. What is the minimum number of carbon atoms required to form an alkyne?
(A) 1
(B) 2
(C) 3
(D) 4

13. Which of the following is the common name for ethyne?
(A) Acetylene
(B) Ethylene
(C) Methane
(D) Propylene

14. Identify the molecular formula of propane.
(A) C_3H_6
(B) C_4H_{10}
(C) C_3H_8
(D) C_2H_6

15. Which of the following statements about alkanes is incorrect?
(A) Highly saturated hydrocarbons with single bonds
(B) Exclusively single covalent bonds between atoms
(C) Characteristic tendency to undergo substitution
(D) Ethane as the simplest alkane member

16. How many covalent bonds are present in a molecule of ethane (C_2H_6)?
(A) 6
(B) 7
(C) 8
(D) 9

17. Consider the following statements regarding alkenes:
I. They are unsaturated hydrocarbons.
II. They contain at least one carbon-carbon triple bond.
III. Their general formula is C_nH_{2n}.
Which of the statements given above is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

18. Which of the following represents a saturated cyclic hydrocarbon?
(A) Benzene
(B) Cyclohexene
(C) Toluene
(D) Cyclohexane

19. What is the molecular formula of cyclohexane?
(A) C_6H_{12}
(B) C_6H_6
(C) C_6H_{10}
(D) C_6H_{14}

20. What is the molecular formula of benzene?
(A) C_6H_{12}
(B) C_6H_{10}
(C) C_6H_6
(D) C_6H_8

21. Aromatic hydrocarbons, like benzene, are primarily characterized by:
(A) A planar ring with conjugated double bonds
(B) Fully open straight-chain hydrocarbon structures containing only single bonds
(C) Complete and high solubility in polar solvent media like pure water
(D) Exceptionally low carbon-to-hydrogen ratios across all structures

22. How many double bonds are present in the stable ring structure of benzene?
(A) 1
(B) 2
(C) 3
(D) 4

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23. Which of the following is considered the simplest and first member of the aromatic hydrocarbon series?
(A) Methane
(B) Benzene
(C) Cyclopropane
(D) Ethyne

24. In IUPAC nomenclature, what prefix is used to denote a continuous chain of 4 carbon atoms?
(A) Prop-
(B) But-
(C) Pent-
(D) Hex-

25. Which suffix is used in the IUPAC naming system to denote the presence of a carbon-carbon triple bond?
(A) -ane
(B) -ene
(C) -ol

(D) -yne

26. Match the chemical formula in List I with its correct IUPAC name in List II.
List I: (Chemical Formula)
P. CH_4
Q. C_2H_6
R. C_3H_8
S. C_4H_{10}
List II: (IUPAC Name)
1. Propane
2. Butane
3. Methane
4. Ethane
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

27. Compounds that have the same molecular formula but different structural formulas are called:
(A) Isotopes
(B) Isomers
(C) Isobars
(D) Allotropes

28. What is the minimum number of carbon atoms required for an alkane to exhibit structural isomerism?
(A) 2
(B) 3
(C) 4
(D) 5

29. How many structural isomers are possible for butane (C_4H_{10})?
(A) 2
(B) 3
(C) 4
(D) 5

30. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Benzene is classified as an aromatic hydrocarbon.
Reason (R): Benzene consists of a continuous straight-chain carbon structure.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

31. Different forms of the same element that have different physical properties but similar chemical properties are known as:
(A) Isomers
(B) Isotopes
(C) Polymers
(D) Allotropes

32. Which allotrope of carbon is recognized as the hardest naturally occurring substance?
(A) Graphite
(B) Fullerene
(C) Diamond
(D) Coal

33. What is the state of hybridization of carbon atoms in diamond?
(A) sp
(B) sp_2
(C) sp_3
(D) sp_3d

34. What is the state of hybridization of carbon atoms in graphite?
(A) sp
(B) sp2
(C) sp3
(D) sp3d2

35. Graphite is a good conductor of electricity. This is primarily due to:
(A) The presence of free, delocalized electrons
(B) Its very high density
(C) Its rigid three-dimensional tetrahedral structure
(D) The presence of ionic bonds

36. Which carbon allotrope is widely used as a dry lubricant for machine parts at high temperatures?
(A) Diamond
(B) Coke
(C) Graphite
(D) Lamp black

37. How many carbon atoms are present in a single molecule of Buckminsterfullerene?
(A) 12
(B) 24
(C) 60
(D) 120

38. The shape of a Buckminsterfullerene molecule is best described as:

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(A) Tetrahedral
(B) Cylindrical tube
(C) Flat hexagonal sheet
(D) Soccer ball (spherical)

39. Which of the following represents the correct order of IUPAC word roots for carbon chains containing 1, 2, 3, and 4 carbon atoms respectively?
(A) Meth, Eth, Prop, But
(B) Eth, Meth, Prop, But
(C) Meth, Prop, Eth, But
(D) But, Prop, Eth, Meth

40. Consider the following statements regarding structural isomers:
I. They have the same molecular formula.
II. They have identical physical and chemical properties.
III. They have different structural arrangements of atoms.
Which of the statements given above is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

41. Carbon nanotubes typically possess which type of structural shape?
(A) Spherical dome
(B) Tetrahedral network
(C) Octahedral
(D) Cylindrical

42. Which of the following is considered an amorphous (non-crystalline) allotrope of carbon?
(A) Coal
(B) Diamond
(C) Graphite
(D) Fullerene

43. What is the primary solid residue left behind after the destructive distillation of coal?
(A) Petrol
(B) Coke
(C) Natural gas
(D) Tar

44. Which carbon allotrope consists of two-dimensional, sheet-like layers of hexagonal arrays?
(A) Diamond
(B) Graphite
(C) Fullerene C_{60}
(D) Carbon nanotube

45. In the crystal structure of diamond, each carbon atom is covalently bonded to how many other carbon atoms?
(A) 2
(B) 3
(C) 4
(D) 6

46. Which gas is exclusively released upon the complete combustion of pure carbon allotropes in excess oxygen?
(A) Carbon monoxide
(B) Methane
(C) Carbon dioxide
(D) Hydrogen gas

47. When comparing the densities of diamond and graphite, which statement is true?
(A) Graphite is much denser than diamond.
(B) Both have the exact same density.
(C) The density of graphite is greater only at high temperatures.
(D) Diamond is denser than graphite.

48. Match the carbon allotropes in List I with their corresponding property or use in List II.
List I: (Carbon Allotrope)
P. Diamond
Q. Graphite
R. Fullerene
S. Coke
List II: (Property / Use)
1. Used as a reducing agent in metallurgy
2. C_{60} spherical molecule
3. Hardest natural substance
4. Good conductor of electricity
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-3, S-1

49. The presence of a six-carbon ring with alternating single and double bonds is the defining feature of which chemical group?
(A) Alkanes
(B) Benzene ring (aromatics)
(C) Cycloalkanes
(D) Alkynes

50. Which specific functional group identifies an organic compound as an alcohol?
(A) -CHO
(B) -COOH

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(C) -O-
(D) -OH

51. Which functional group is the defining characteristic of carboxylic acids?
(A) -COOH
(B) -OH
(C) -CHO
(D) >C=O

52. What is the standard IUPAC name for acetic acid?
(A) Methanoic acid
(B) Propanoic acid
(C) Ethanoic acid
(D) Butanoic acid

53. Which of the following is the correct molecular formula for ethanol?
(A) C_2H_5OH
(B) CH_3OH
(C) C_3H_7OH
(D) C_2H_4O

54. Methanol is highly toxic to humans primarily because it is oxidized in the liver to form which harmful compound?
(A) Ethanoic acid
(B) Carbon monoxide
(C) Methane
(D) Methanal (Formaldehyde)

55. Commercial ethanol is sometimes made deliberately unfit for drinking by adding poisonous substances like methanol or copper sulphate. This mixture is called:
(A) Absolute alcohol
(B) Denatured alcohol
(C) Rectified spirit
(D) Power alcohol

56. The chemical reaction between a carboxylic acid and an alcohol, typically in the presence of an acid catalyst, forms a new compound known as:
(A) A ketone
(B) An ether
(C) An ester
(D) An aldehyde

57. Esters are most commonly recognized in everyday chemistry by their:
(A) Pungent, suffocating odor
(B) Ability to conduct electricity
(C) Extreme hardness
(D) Sweet, fruity smell

58. The alkaline hydrolysis of an ester, using sodium hydroxide to produce a sodium salt of a carboxylic acid and an alcohol, is known as:
(A) Saponification
(B) Esterification
(C) Fermentation
(D) Hydrogenation

59. Consider the following statements about fullerenes:
I. The first fullerene to be identified was C-60.
II. They are named after the American architect Buckminster Fuller.
III. They possess a purely two-dimensional planar structure.
Which of the statements given above is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

60. A dilute solution containing 5 to 8 percent of acetic acid in water is commonly used in households as:
(A) Rubbing alcohol
(B) Vinegar
(C) Baking soda
(D) Bleach

61. Which industrial process is primarily used for separating crude petroleum into its various useful fractions?
(A) Fractional distillation
(B) Simple distillation
(C) Filtration
(D) Centrifugation

62. The separation of petroleum fractions during refining is fundamentally based on the differences in their:
(A) Densities
(B) Melting points
(C) Boiling points
(D) Solubilities

63. During the fractional distillation of petroleum, which fraction comes out at the lowest temperature (lowest boiling point)?
(A) Diesel oil
(B) Kerosene
(C) Lubricating oil
(D) Petroleum gas

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64. The thick, black, viscous residue left at the bottom of the fractionating column after petroleum distillation is mainly used for:
(A) Aviation fuel
(B) Cooking gas
(C) Road surfacing (Bitumen)
(D) Dry cleaning

65. What are the main constituent gases found in Liquefied Petroleum Gas (LPG) cylinders used for domestic cooking?
(A) Methane and Ethane
(B) Butane and Propane
(C) Carbon monoxide and Hydrogen
(D) Nitrogen and Oxygen

66. The primary hydrocarbon component of Compressed Natural Gas (CNG) is:
(A) Propane
(B) Butane
(C) Hexane
(D) Methane

67. In the context of Rajasthan, which basin is recognized as a major hub for crude oil and petroleum reserves?
(A) Barmer-Sanchore basin
(B) Hadoti basin
(C) Shekhawati basin
(D) Mewar basin

68. Match the petroleum fraction in List I with its primary use in List II.
List I: (Petroleum Fraction)
P. LPG
Q. Petrol (Gasoline)
R. Diesel
S. Bitumen
List II: (Primary Use)
1. Fuel for heavy motor vehicles
2. Surfacing of roads
3. Fuel for home and industry
4. Fuel for light motor vehicles
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-1, R-4, S-2

69. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Compressed Natural Gas (CNG) is considered an excellent and clean transport fuel.
Reason (R): CNG undergoes near-complete combustion and leaves behind very little unburnt carbon and polluting gases compared to petrol or diesel.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

70. The complete combustion of hydrocarbon fuels in the presence of adequate oxygen yields which primary chemical products?
(A) Carbon monoxide and water
(B) Pure carbon (soot) and hydrogen gas
(C) Methane and oxygen
(D) Carbon dioxide and water

71. The incomplete combustion of carbon-based fuels in limited oxygen yields which highly toxic gas?
(A) Carbon dioxide
(B) Carbon monoxide
(C) Nitrogen dioxide
(D) Sulphur dioxide

72. Why is carbon monoxide exceptionally harmful when inhaled by humans?
(A) It severely irritates the lining of respiratory airways and triggers instant asthma attacks.
(B) It dissolves rapidly into blood plasma to generate highly corrosive carbonic acid solutions.
(C) It binds to hemoglobin, preventing oxygen transport.
(D) It rapidly destroys white blood cells upon contact with systemic circulation.

73. The excessive release of which gas from the burning of fossil fuels is considered the primary driver of the enhanced greenhouse effect and global warming?
(A) Carbon monoxide
(B) Sulphur dioxide
(C) Nitrogen
(D) Carbon dioxide

74. Biofuels are distinct from traditional fossil fuels because they are derived from:
(A) Recent biological matter or biomass
(B) Prehistoric organic plant and animal matter buried deep underground for millions of years

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(C) Complex synthetic chemical compounds manufactured artificially in industrial laboratories
(D) Heavy radioactive elements such as uranium extracted from deep geological formations

75. Which liquid biofuel is most commonly blended with petrol in India to reduce reliance on imported crude oil and lower tailpipe emissions?
(A) Methanol
(B) Ethanol
(C) Propanol
(D) Butanol

76. In regions like Rajasthan, which drought-resistant plant is heavily promoted and cultivated as a primary feedstock for biodiesel production?
(A) Wheat
(B) Jatropha (Ratanjot)
(C) Sugarcane
(D) Cotton

77. First-generation biofuels are primarily manufactured from which type of raw material?
(A) Edible food crops rich in starch or sugars
(B) Non-edible agricultural crop residues and forestry waste products
(C) Microscopic algae cultivated intensively in industrial wastewater streams
(D) Post-consumer non-biodegradable municipal plastic waste streams

78. Consider the following statements regarding biofuels:
I. They are considered a renewable source of energy.
II. Blending ethanol with petrol can help reduce carbon monoxide emissions.
III. They are extracted directly from deep underground oil wells.
Which of the statements given above is/are correct?
(A) I only
(B) I and II only
(C) II and III only
(D) I, II and III

79. The term "Gasohol," widely used in the context of alternative fuels, refers to a blend of:
(A) Commercial diesel fuel blended with industrial kerosene
(B) Compressed natural gas mixed with refined petrol
(C) Renewable biodiesel combined with conventional diesel
(D) Petrol and ethanol

80. The continuous movement of carbon through the Earth's atmosphere, biosphere, oceans, and geosphere is formally known as the:
(A) Nitrogen cycle
(B) Oxygen cycle
(C) Carbon cycle
(D) Water cycle

81. Which biological process plays a critical role in removing carbon dioxide from the atmosphere during the carbon cycle?
(A) Respiration
(B) Photosynthesis
(C) Combustion
(D) Decomposition

82. Which of the following natural processes returns carbon dioxide back to the atmosphere?
(A) Photosynthesis in green plants
(B) Formation of fossil fuels underground
(C) Conversion of carbon into carbonates in the ocean
(D) Respiration by plants and animals

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83. When comparing the physical properties of typical organic and inorganic compounds, organic compounds generally exhibit:
(A) Lower melting and boiling points
(B) Much higher melting and boiling points
(C) Equal melting and boiling points
(D) Infinite solubility in water

84. The low melting and boiling points of most organic carbon compounds are a consequence of:
(A) The presence of extremely strong electrostatic ionic bonds holding adjacent molecules
(B) Exceptionally high atomic masses characteristic of heavy constituent elements
(C) Weak intermolecular forces between molecules
(D) High electronegativity values associated with bonded carbon atoms

85. In their pure, undissolved state, most covalent organic compounds are:
(A) Poor conductors of electricity
(B) Excellent conductors of electricity
(C) Superconductors at room temperature
(D) Highly magnetic

86. According to standard IUPAC nomenclature, if a hydrocarbon chain contains a carbon-carbon

double bond, the name of the compound will end with the suffix:
(A) -ane
(B) -yne
(C) -one
(D) -ene

87. Match the historical milestone or discovery in List I with the corresponding scientist/concept in List II.
List I: (Historical Milestone / Discovery)
P. Vital Force Theory proponent
Q. First synthesis of an organic compound (Urea)
R. Shape inspiration for C-60 molecule
S. Discovery of Carbon Nanotubes
List II: (Scientist / Concept)
1. Friedrich Wöhler
2. J.J. Berzelius
3. Sumio Iijima
4. Geodesic dome architecture
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

88. A homologous series is a group of organic compounds having a similar structure and chemical properties. Successive members of a homologous series differ by which specific structural unit?
(A) -CH
(B) $-CH_3$
(C) $-CH_2$
(D) $-C_2H_4$

89. Match the name of the organic functional group in List I with its correct chemical symbol in List II.
List I: (Functional Group)
P. Alcohol
Q. Aldehyde
R. Ketone
S. Carboxylic Acid
List II: (Chemical Symbol)
1. -CHO
2. -OH
3. -COOH
4. >C=O
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

90. Which organic compound is extensively used as a primary industrial solvent, the main active ingredient in hand sanitizers, and in the production of alcoholic beverages?
(A) Ethanol
(B) Methanol
(C) Ethanoic acid
(D) Propanone

91. What is the correct IUPAC name for chloroform, a compound historically used as an anesthetic?
(A) Chloromethane
(B) Dichloromethane
(C) Trichloromethane
(D) Tetrachloromethane

92. The non-stick coating on modern cookware, commonly known as Teflon, is a polymer made from which carbon-based monomer?
(A) Vinyl chloride
(B) Tetrafluoroethylene
(C) Ethylene
(D) Propylene

93. Identify the odd one out from the following list based on the saturation of the hydrocarbon chain.
(A) Ethene
(B) Methane
(C) Ethane
(D) Propane

94. The unique atomic property that allows a single carbon atom to directly bond with up to four other atoms (including other carbons) is called:
(A) Catenation
(B) Electronegativity
(C) Tetravalency
(D) Hybridization

95. A covalent bond is fundamentally formed by:
(A) The complete transfer of electrons from one atom to another
(B) The electrostatic attraction of oppositely charged ions
(C) The flow of free electrons in a metallic lattice
(D) The sharing of electron pairs between two atoms

96. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Exposure to carbon monoxide gas in an enclosed space can be fatal.
Reason (R): Carbon monoxide binds with the

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hemoglobin in blood much more strongly than oxygen does, preventing the delivery of oxygen to body tissues.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

97. Identify the incorrect pair regarding the standard IUPAC word prefix and its corresponding number of carbon atoms.
(A) Meth - 1 carbon
(B) Eth - 2 carbons
(C) Prop - 4 carbons
(D) But - 4 carbons

98. Arrange the following steps logically to represent a simplified path in the carbon cycle:
1. Photosynthesis by plants
2. Atmospheric Carbon Dioxide
3. Combustion of fossil fuels
4. Fossilization of dead plant matter underground
(A) 2, 1, 4, 3
(B) 1, 2, 3, 4
(C) 4, 3, 2, 1
(D) 2, 4, 1, 3

99. The electronic configuration of a carbon atom is 2, 4. To achieve a stable noble gas configuration, how many electrons does it need to share?
(A) 2
(B) 4
(C) 6
(D) 8

100. In a carbon-carbon double covalent bond (such as in ethene), exactly how many pairs of electrons are shared between the two carbon atoms?
(A) One pair
(B) Two pairs
(C) Three pairs
(D) Four pairs

101. Which of the following naturally occurring minerals is NOT an allotrope of carbon?
(A) Quartz
(B) Diamond
(C) Graphite
(D) Coal

102. The compounds n-pentane, isopentane, and neopentane share the same molecular formula (C_5H_{12}) but have different structures. They are best classified as:
(A) Geometric isomers
(B) Isotopes
(C) Homologues
(D) Structural isomers

103. The general formula for cycloalkanes (such as cyclopentane or cyclohexane) is mathematically identical to the general formula of which open-chain hydrocarbon series?
(A) Alkanes
(B) Alkenes
(C) Alkynes
(D) Arenes (Aromatics)

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104. A single molecule of benzene (C_6H_6) is composed of exactly:
(A) 6 carbon atoms and 12 hydrogen atoms
(B) 6 carbon atoms and 6 hydrogen atoms
(C) 6 carbon atoms and 10 hydrogen atoms
(D) 12 carbon atoms and 6 hydrogen atoms

105. Which highly flammable gas, naturally produced by the decomposition of organic matter in swamps and wetlands, is commonly known as "marsh gas"?
(A) Ethane
(B) Propane
(C) Butane
(D) Methane

106. When unsaturated hydrocarbons undergo combustion in a normal air supply, they characteristically produce a:
(A) Yellow, sooty flame
(B) Non-luminous blue flame
(C) Brilliant white, smokeless flame
(D) Green flame

107. During the laboratory preparation of an ester (esterification), what is the primary role of concentrated sulfuric acid?
(A) It acts as a powerful oxidizing agent in the solution
(B) Catalyst and dehydrating agent
(C) It functions primarily as a reaction solvent medium
(D) It acts as a strong reducing agent during the process

108. Match the common everyday name in List I with its correct chemical or IUPAC name in List II.
List I: (Common Name)
P. Vinegar (active component)

Q. Grain alcohol
R. Wood spirit
S. Marsh gas

List II: (Chemical / IUPAC Name)

1. Methane
2. Methanol
3. Ethanol
4. Ethanoic acid

(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

109. Consider the following statements about the element Carbon:

I. It predominantly forms ionic compounds.
II. Its atomic number is 6.
III. It belongs to Group 14 of the modern periodic table.

Which of the statements given above is/are correct?

(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

110. Identify the correct statement about graphite among the following options:

(A) It possesses a rigid three-dimensional tetrahedral covalent lattice throughout
(B) It is widely recognized as the hardest naturally occurring substance on Earth
(C) It contains free electrons that conduct electricity
(D) It is strictly classified as an inorganic ionic compound in standard mineralogy

111. Match the hydrocarbon series in List I with its correct general formula in List II.

List I: (Hydrocarbon Series)

P. Alkanes
Q. Alkenes
R. Alkynes
S. Cycloalkanes

List II: (General Formula)

1. C_nH_{2n}
2. C_nH_{2n-2}
3. C_nH_{2n+2}

(A) P-3, Q-1, R-2, S-1
(B) P-1, Q-2, R-3, S-1
(C) P-3, Q-2, R-1, S-3
(D) P-2, Q-1, R-3, S-2

112. Which of the following elements is invariably present in the molecular structure of all organic compounds?

(A) Oxygen
(B) Nitrogen
(C) Carbon
(D) Sulfur

113. Polyvinyl chloride (PVC), widely used in making pipes, is a polymer derived from which specific carbon-based monomer?

(A) Tetrafluoroethylene
(B) Vinyl chloride (Chloroethene)
(C) Isoprene
(D) Ethylene

114. Select the correct order of the first four straight-chain alkanes arranged in increasing order of their boiling points.

(A) Butane < Propane < Ethane < Methane
(B) Methane < Ethane < Propane < Butane
(C) Ethane < Methane < Butane < Propane
(D) Methane < Propane < Ethane < Butane

115. Based on the general formulas for hydrocarbons, which of the following molecular formulas correctly represents an alkyne?

(A) C_3H_4
(B) C_2H_6
(C) C_3H_6
(D) C_4H_{10}

116. Arrange the following petroleum fractions in the increasing order of their boiling points (lowest boiling point to highest boiling point) during fractional distillation:

1. Diesel
2. Petroleum gas
3. Lubricating oil
4. Petrol (Gasoline)

(A) 2, 4, 1, 3
(B) 4, 2, 1, 3
(C) 2, 1, 4, 3
(D) 1, 2, 4, 3

117. When ethanol is heated with excess concentrated sulfuric acid at a high temperature (443 K), it undergoes dehydration. What is the primary organic gas produced in this reaction?

(A) Ethene
(B) Ethane
(C) Methane
(D) Ethyne

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118. Which two specific properties of carbon together enable it to form the millions of organic compounds known today?
(A) High density and malleability
(B) High boiling point and ionic bonding
(C) Electronegativity and diamagnetism
(D) Catenation and tetravalency

119. What is the most significant global environmental concern associated with the large-scale extraction and combustion of fossil hydrocarbon fuels?
(A) Severe and rapid depletion of total atmospheric oxygen levels worldwide
(B) Release of greenhouse gases causing global warming
(C) Direct destruction of the stratospheric ozone layer by fine unburnt carbon particles
(D) The continuous generation and hazardous accumulation of radioactive nuclear waste

120. Second-generation biofuels represent an advancement over first-generation fuels primarily because they are:
(A) Manufactured exclusively from edible food crops rich in starch or sugars like corn and sugarcane
(B) Extracted directly from deeper underground coal seams and petroleum reserves
(C) Derived from non-food biomass like agricultural waste
(D) Synthesized completely in advanced industrial laboratories without requiring any biological input

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ANSWERS

1. (B) 6
Carbon is a chemical element represented by the symbol C in the periodic table. The atomic number of any chemical element is defined as the total number of protons found in the nucleus of an atom. Carbon contains six protons in its atomic nucleus, giving it an atomic number of six.

2. (C) 4
The valency of an element reflects its bonding capacity to achieve a stable electronic configuration. Carbon has an atomic number of six, giving it an electronic structure of two and four. Consequently, carbon requires four additional electrons to complete its valence shell, exhibiting tetravalency by sharing four electrons in organic compounds.

3. (A) Catenation
Catenation is the self-linking capability of atoms of an element to form covalent bonds with each other, resulting in open chains, branched frameworks, or cyclic structures. Carbon possesses an exceptionally high degree of catenation due to its small atomic size and strong carbon to carbon single bonds, allowing the formation of diverse organic molecules.

4. (C) Covalent bond
Carbon has four valence electrons in its outermost energy level. Gaining or losing four electrons requires an exceptionally high amount of energy, making ionic bond formation thermodynamically unfavorable. Instead, carbon achieves a stable octet configuration by sharing pairs of electrons with other carbon atoms or different elements, forming predominantly strong covalent bonds.

5. (A) Low melting and boiling points
Organic compounds consist predominantly of molecules held together by covalent chemical bonds rather than ionic bonds. The intermolecular forces between discrete covalent molecules, such as dispersion forces or dipole interactions, are relatively weak. Consequently, minimal thermal energy is required to break these weak interactions, leading to characteristic low melting and boiling points.

6. (D) CnH_{2n+2}
Saturated open chain hydrocarbons, commonly known as alkanes, contain only single covalent bonds between carbon atoms. Each carbon atom maximizes its bonded hydrogen count to maintain tetravalency. For an alkane containing n carbon atoms, the number of hydrogen atoms required to saturate the aliphatic chain corresponds precisely to two n plus two.

7. (A) P-4, Q-1, R-2, S-3
Hydrocarbons are classified into specific chemical series according to their bonding structures. Ethane is a saturated alkane containing single bonds. Ethene is an alkene possessing a carbon to carbon double bond. Ethyne is an alkyne containing a carbon to carbon triple bond. Benzene is an aromatic hydrocarbon featuring a planar ring with delocalized electrons.

8. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Carbon has four valence electrons and requires four additional electrons to achieve a stable octet. Removing four electrons to form a positive ion requires immense energy, while gaining four electrons to form a negative ion causes electron repulsion. Thus, carbon shares electrons to satisfy tetravalency, making covalent bonding the primary mode of bonding.

9. (D) Clean blue flame
Saturated hydrocarbons possess a relatively high proportion of hydrogen to carbon in their molecular structures. When burned in the presence of sufficient oxygen, they undergo complete oxidation. Complete combustion converts all carbon into carbon dioxide and hydrogen into water vapor, producing an efficient, non-sooty, clean blue flame without leftover unburnt carbon.

10. (A) Carbon-carbon double or triple bonds
Unsaturated hydrocarbons are organic compounds containing fewer hydrogen atoms than the maximum possible capacity for a given carbon skeleton. This hydrogen deficit necessitates the formation of multiple covalent bonds between adjacent carbon atoms.

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Consequently, unsaturated hydrocarbons are structurally characterized by the presence of at least one carbon to carbon double or triple bond.

11. (B) C_nH_{2n}
Alkenes are unsaturated acyclic hydrocarbons containing exactly one carbon to carbon double bond within their carbon skeleton. The introduction of a double bond reduces the number of hydrogen atoms by two compared to corresponding alkanes. Therefore, for an open chain alkene containing n carbon atoms, the general molecular formula is expressed as C_nH_{2n}.

12. (B) 2
Alkynes are unsaturated hydrocarbons defined by the presence of at least one carbon to carbon triple bond. A triple bond requires two adjacent carbon atoms to share three pairs of electrons between them. Consequently, a minimum of two carbon atoms is structurally necessary to construct the simplest functional alkyne molecule, known as ethyne.

13. (A) Acetylene
Ethyne is the simplest member of the alkyne family, possessing the molecular formula C_2H_2 with a carbon to carbon triple bond. In industrial and non-systematic chemical terminology, ethyne is widely known by its common name, acetylene. Acetylene is extensively utilized in gas torches for high temperature metal welding and cutting operations.

14. (C) C_3H_8
Propane is a saturated open chain hydrocarbon belonging to the alkane homologous series. The prefix prop denotes a main continuous chain containing three carbon atoms. Applying the general formula for alkanes, C_nH_{2n+2}, where n equals three, yields three carbon atoms and eight hydrogen atoms, resulting in the molecular formula C_3H_8.

15. (D) Ethane as the simplest alkane member
Alkanes are saturated hydrocarbons containing exclusively single covalent bonds between atoms and typically undergo substitution reactions under suitable conditions. The simplest member of the alkane homologous series is methane, which contains a single carbon atom bonded to four hydrogen atoms, whereas ethane contains two carbon atoms and constitutes the second member.

16. (B) 7
Ethane has the molecular formula C_2H_6. The structural arrangement consists of two carbon atoms connected to each other by a single carbon to carbon covalent bond. In addition, each carbon atom forms single covalent bonds with three individual hydrogen atoms. Summing the single carbon bond and six carbon hydrogen bonds gives seven total covalent bonds.

17. (C) I and III only
Alkenes are unsaturated hydrocarbons containing at least one carbon to carbon double bond, rather than a triple bond. Their aliphatic open chain structures conform strictly to the general molecular formula C_nH_{2n}. Hydrocarbons with triple bonds belong to the alkyne family, making double bonds the defining structural feature separating alkenes from other unsaturated hydrocarbons.

18. (D) Cyclohexane
Saturated cyclic hydrocarbons consist of carbon atoms arranged in a closed ring system containing only single covalent bonds between carbon atoms. Cyclohexane features a ring of six carbon atoms connected entirely by single bonds, satisfying saturation. In contrast, benzene, cyclohexene, and toluene contain double bonds within their respective cyclic carbon frameworks.

19. (A) C_6H_{12}
Cyclohexane is a cycloalkane composed of six carbon atoms joined in a saturated ring structure. Cycloalkanes follow the general formula C_nH_{2n} because ring closure requires two fewer hydrogen atoms than an open chain alkane. Substituting n equals six into this general formula yields six carbon atoms and twelve hydrogen atoms, giving C_6H_{12}.

20. (C) C_6H_6
Benzene is a fundamental aromatic hydrocarbon consisting of a hexagonal ring formed by six carbon atoms. Each carbon atom in the ring is attached to a single hydrogen atom. The continuous delocalization of six pi electrons across the cyclic structure results in equal carbon to carbon bond lengths, giving the molecular formula C_6H_6.

21. (A) A planar ring with conjugated double bonds
Aromatic hydrocarbons such as benzene feature a cyclic, planar ring structure stabilized by

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resonance and conjugated pi electron systems. The alternating system of double and single bonds allows delocalization of electrons across the ring, granting exceptional chemical stability. This planar ring arrangement with conjugated pi bonds defines the structural behavior of aromatic systems.

22. (C) 3
Benzene is represented structurally as a six membered carbon ring containing alternating single and double covalent bonds. In standard structural representations, this arrangement corresponds to three carbon to carbon double bonds and three carbon to carbon single bonds. The pi electrons from these three double bonds delocalize around the ring, contributing to aromatic stability.

23. (B) Benzene
Benzene, with its molecular formula C_6H_6, represents the simplest parent compound of the aromatic hydrocarbon series. It contains a stable six membered planar carbon ring characterized by delocalized pi electron clouds. Other aromatic compounds are frequently derived by substituting one or more hydrogen atoms on the benzene ring with various functional groups.

24. (B) But-
In standard IUPAC organic chemical nomenclature, specific root prefixes designate the exact number of continuous carbon atoms present in the principal carbon chain. The prefix meth denotes one carbon atom, eth denotes two, prop denotes three, and but denotes four carbon atoms in an uninterrupted sequence within an organic compound.

25. (D) -yne
Systematic IUPAC nomenclature utilizes distinctive suffixes to identify the primary functional groups or degree of unsaturation present in hydrocarbon chains. The suffix ane indicates saturated carbon chains containing single bonds, ene indicates the presence of a double bond, and yne specifies the presence of a carbon to carbon triple bond in alkynes.

26. (A) P-3, Q-4, R-1, S-2
Straight chain alkanes follow systematic IUPAC nomenclature derived from their carbon count. CH_4 contains one carbon atom and is named methane. C_2H_6 contains two carbon atoms and is named ethane. C_3H_8 contains three carbon atoms and is named propane. C_4H_{10} contains four carbon atoms and is named butane in the alkane series.

27. (B) Isomers
Organic compounds sharing an identical chemical formula but possessing distinct structural formulas or spatial arrangements are known as isomers. This phenomenon, called isomerism, arises because identical sets of atoms can bond in different structural connectivity sequences, leading to isomeric substances that display distinct physical and chemical properties from one another.

28. (C) 4
Structural isomerism requires the possibility of arranging carbon atoms in different structural frameworks, such as straight and branched chains. Methane, ethane, and propane possess only one possible structural arrangement each. Butane, containing four carbon atoms, is the smallest alkane that forms two distinct structural isomers, namely normal butane and isobutane.

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29. (A) 2
Butane has the molecular formula C_4H_{10} and exhibits structural isomerism. The four carbon atoms can form either a straight continuous chain or a branched carbon skeleton. The straight chain isomer is designated as normal butane, while the branched chain isomer is methylpropane, commonly called isobutane. Thus, exactly two structural isomers exist for butane.

30. (C) Assertion (A) is true but Reason (R) is false.
Benzene is classified as an aromatic hydrocarbon because it possesses a cyclic, planar ring system stabilized by delocalized pi electrons. It does not consist of an open straight chain carbon framework. Structural circularity and aromatic resonance are essential characteristics of benzene, making straight chain structural claims incorrect for this aromatic system.

31. (D) Allotropes
Allotropy is the property exhibited by certain chemical elements that exist in two or more different structural forms within the same physical state. These distinct physical forms are called allotropes. Allotropes differ significantly in their physical properties due to varied atomic

arrangements, yet exhibit similar chemical behavior because they consist of identical atoms.

32. (C) Diamond
Diamond is a crystalline allotrope of carbon recognized as the hardest naturally occurring substance known. In diamond, each carbon atom is bonded to four neighboring carbon atoms in a rigid, three dimensional tetrahedral lattice. This continuous network of strong covalent bonds imparts extreme mechanical hardness, high density, and high melting thermal resistance.

33. (C) sp3
In diamond, every carbon atom forms four single covalent sigma bonds with four surrounding carbon atoms arranged tetrahedrally. To accommodate four equivalent sigma bonds directed toward tetrahedral vertices, the one s orbital and three p orbitals of carbon hybridize completely, giving rise to sp3 hybridization for all carbon atoms in diamond.

34. (B) sp2
In graphite, each carbon atom is covalently bonded to three adjacent carbon atoms within a planar hexagonal sheet. This trigonal planar geometry involves the hybridization of one s orbital and two p orbitals, resulting in sp2 hybridization. The remaining unhybridized p orbital contains a delocalized electron responsible for conduction between layers.

35. (A) The presence of free, delocalized electrons
In graphite, each sp2 hybridized carbon atom forms three covalent bonds with adjacent carbon atoms in planar hexagonal layers. The fourth valence electron occupies an unhybridized p orbital perpendicular to the layer plane. These p electrons become delocalized across the hexagonal sheets, moving freely and conducting electricity efficiently through the lattice.

36. (C) Graphite
Graphite consists of stacked hexagonal carbon layers bound together by weak van der Waals forces. These weak interlayer forces allow the parallel carbon sheets to slide smoothly over one another under pressure. Due to its high thermal stability and slippery nature, graphite is widely employed as an effective dry lubricant.

37. (C) 60
Buckminsterfullerene is a discrete, soccer ball shaped allotrope of carbon consisting of exactly sixty carbon atoms arranged in a hollow cage. Designated formulaically as C_{60}, this spherical fullerene molecule features twenty hexagonal rings and twelve pentagonal rings fused together in a closed geodesic structure discovered by Kroto, Curl, and Smalley.

38. (D) Soccer ball (spherical)
Buckminsterfullerene, C_{60}, possesses a highly symmetrical hollow cage geometry composed of fused pentagonal and hexagonal carbon rings. This specific arrangement of interconnected rings closely resembles the surface pattern and shape of a standard soccer ball, often referred to geometrically as a truncated icosahedron or spherical fullerene molecule.

39. (A) Meth, Eth, Prop, But
Standard IUPAC rules dictate specific word roots based on the total number of carbon atoms present in the principal continuous chain. A one carbon chain uses the root meth, a two carbon chain uses eth, a three carbon chain uses prop, and a four carbon chain uses but in chemical naming sequence.

40. (C) I and III only
Structural isomers are distinct chemical compounds that share the exact same molecular formula but feature different structural arrangements of their constituent atoms. Because structural isomers possess different atomic connectivity, branching, or functional group placements, they display markedly different physical and chemical properties rather than identical chemical characteristics.

41. (D) Cylindrical
Carbon nanotubes are cylindrical fullerenes consisting of rolled up sheets of single layer sp2 hybridized carbon atoms, known as graphene. These tubular nanostructures feature high length to diameter aspect ratios, seamless cylindrical walls, extraordinary tensile strength, and unique electronic transport properties suitable for advanced nanotechnology and materials science applications.

42. (A) Coal
Carbon allotropes are categorized as crystalline or amorphous based on structural order. Diamond, graphite, and fullerenes possess well defined, repeating crystalline lattice arrangements. Coal, along with charcoal, lampblack, and coke, lacks

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long range crystalline order and is classified as an amorphous or non-crystalline form of elemental carbon mixed with impurities.

43. (B) Coke
Destructive distillation involves heating coal to extremely high temperatures in the absence of air. This pyrolysis process drives off volatile components such as coal tar, coal gas, and ammonia. The solid, porous, carbon rich material remaining in the retort after driving off all volatile matter is coke, used in steel production.

44. (B) Graphite
Graphite features a two dimensional layered crystal structure composed of flat, hexagonal networks of sp2 hybridized carbon atoms. Within each individual layer, carbon atoms are strongly bonded covalently. However, the separate stacked two dimensional sheets are held together by weak van der Waals forces, permitting lateral cleavage and slippery mechanical behavior.

45. (C) 4
In the crystal lattice of diamond, each carbon atom undergoes sp3 hybridization and forms strong covalent single bonds with four neighboring carbon atoms. These four surrounding atoms are arranged at equal angles toward the vertices of a regular tetrahedron, creating a continuous three dimensional network responsible for diamond's extreme hardness.

46. (C) Carbon dioxide
Elemental carbon allotropes, including diamond, graphite, and fullerenes, consist exclusively of carbon atoms. When any pure carbon allotrope is subjected to complete combustion in the presence of excess oxygen gas, all carbon atoms undergo complete oxidation, releasing carbon dioxide gas as the sole chemical reaction product without residual moisture.

47. (D) Diamond is denser than graphite.
In diamond, carbon atoms form a tightly packed, three dimensional tetrahedral covalent network with small interatomic distances. Conversely, graphite consists of widely spaced, two dimensional carbon sheets held apart by weak van der Waals forces. Consequently, diamond has a significantly higher physical density than graphite due to its compact spatial packing.

48. (A) P-3, Q-4, R-2, S-1
Carbon allotropes display distinct properties and industrial applications. Diamond is the hardest naturally occurring substance. Graphite contains delocalized electrons, making it a good electrical conductor. Fullerene exists as spherical C_{60} molecules. Coke is a porous carbon material heavily utilized as a reducing agent in metallurgical extraction processes.

49. (B) Benzene ring (aromatics)
A planar six carbon cyclic structure featuring alternating single and double bonds represents the classical Kekulé depiction of a benzene ring. This conjugated system leads to delocalization of pi electrons across the ring, granting aromatic stability. This cyclic structural unit is the defining characteristic of aromatic organic compounds.

50. (D) -OH
An alcohol is an organic compound containing a hydroxyl functional group, denoted chemically as -OH, covalently attached to a saturated carbon atom. The presence of this polar hydroxyl group governs the physical properties, hydrogen bonding capabilities, and characteristic chemical reactivity exhibited by the alcohol homologous series in chemistry.

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51. (A) -COOH
Carboxylic acids are organic compounds containing a carboxyl functional group, represented as -COOH. The carboxyl group consists of a carbonyl group, C=O, directly attached to a hydroxyl group, -OH. This functional unit imparts weak acidic properties, enabling carboxylic acids to donate protons in aqueous chemical reactions.

52. (C) Ethanoic acid
Acetic acid contains a two carbon chain including the carboxyl carbon atom, represented by the structural formula CH_3COOH. According to systematic IUPAC nomenclature rules, a two carbon organic acid derives its name from the parent alkane ethane, replacing the final suffix -e with -oic acid to yield ethanoic acid.

53. (A) C_2H_5OH
Ethanol is a primary two carbon alcohol comprising an ethyl group attached to a hydroxyl functional group. Its condensed structural formula is CH_3CH_2OH, which combines to give the molecular formula C_2H_5OH. Ethanol is the

alcohol found in alcoholic beverages and is widely used as a solvent and industrial chemical fuel.

54. (D) Methanal (Formaldehyde)
When ingested, methanol is metabolized in the human liver by the enzyme alcohol dehydrogenase. This biochemical oxidation process converts methanol into methanal, commonly known as formaldehyde. Methanal reacts rapidly with cellular components, coagulating protoplasm, damaging the optic nerve to cause blindness, and ultimately resulting in severe systemic toxicity.

55. (B) Denatured alcohol
To prevent the industrial tax free use of ethanol for human consumption, additives such as toxic methanol, pyridine, or copper sulphate are deliberately added to it. This process renders the ethanol poisonous, foul smelling, and visually altered. The resulting unfit alcohol blend is commercially referred to as denatured alcohol.

56. (C) An ester
The chemical reaction between a carboxylic acid and an alcohol in the presence of an acid catalyst is known as esterification. During this condensation reaction, a molecule of water is eliminated, joining the acyl group of the acid to the alkoxy group of the alcohol to form an ester.

57. (D) Sweet, fruity smell
Esters are volatile organic compounds characterized by pleasant, sweet, and fruity fragrances. Because of these distinct aromatic properties, esters occur naturally in ripe fruits and flowers. They are widely synthesized industrially for use as artificial flavoring agents, food additives, synthetic fragrances, and ingredients in commercial perfumes.

58. (A) Saponification
Saponification is the alkaline hydrolysis of an ester, typically achieved by heating it with a strong base like sodium hydroxide. This reaction breaks the ester bond, yielding an alcohol and the alkali metal salt of the carboxylic acid. It is traditionally used in soap manufacturing using fat esters.

59. (A) I and II only
Buckminsterfullerene, designated C_{60}, was the first identified fullerene allotrope and was named in honor of architect R. Buckminster Fuller due to its structural resemblance to geodesic domes. Fullerenes are three dimensional, closed cage spherical or ellipsoidal molecules composed of fused carbon rings, making claims of planar two dimensional structures incorrect.

60. (B) Vinegar
A dilute aqueous solution containing approximately five to eight percent ethanoic acid, commonly called acetic acid, by volume is household vinegar. Vinegar is widely used in culinary applications as a food preservative, flavoring agent, and condiment due to its mild acidity and ability to inhibit microbial bacterial growth.

61. (A) Fractional distillation
Petroleum is a complex mixture of various liquid, gaseous, and solid hydrocarbons. Refining petroleum into separate useful fractions, such as petrol, kerosene, and diesel, is performed using fractional distillation. This continuous thermal separation process utilizes a tall fractionating column to separate hydrocarbons based on their varying boiling points.

62. (C) Boiling points
The separation of crude petroleum into distinct functional fractions during industrial refining relies directly on differences in boiling points among component hydrocarbons. As crude oil is heated inside a tall fractionating column, compounds condense at different height levels corresponding to their specific temperature ranges and molecular chain lengths.

63. (D) Petroleum gas
In fractional distillation of crude oil, light hydrocarbon fractions with low molecular weights and small carbon chain length vaporize most readily. Petroleum gas, consisting primarily of low boiling gases like propane and butane, collects at the top of the fractionating column at temperatures below twenty degrees Celsius as the lowest boiling fraction.

64. (C) Road surfacing (Bitumen)
Bitumen is a dark, highly viscous, non-volatile hydrocarbon residue left at the base of fractional distillation towers during petroleum refining. Due to its high water resistance, durability, and strong adhesive properties, bitumen is extensively utilized as a binding material in road construction, paving, and industrial waterproofing applications.

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65. (B) Butane and Propane
Liquefied Petroleum Gas, commonly abbreviated as LPG, is a flammable hydrocarbon gas mixture widely utilized for domestic cooking and heating. The predominant chemical components of LPG are butane and propane gases, which are easily compressed into liquid form under moderate pressure for convenient storage and transportation in steel cylinders.

66. (D) Methane
Compressed Natural Gas, commonly known as CNG, is a fossil fuel alternative stored under high pressure. The primary chemical constituent of natural gas is methane, CH_4, typically accounting for eighty to ninety-five percent of its overall volume, along with minor proportions of other light alkanes like ethane and propane.

67. (A) Barmer-Sanchore basin
The Barmer-Sanchore basin located in western Rajasthan is recognized as a major onshore hydrocarbon province in India. Extensive geological exploration and drilling operations in this basin have revealed massive crude oil reserves, including major producing oil fields such as Mangala, Bhagyam, and Aishwarya operated for industrial petroleum production.

68. (A) P-3, Q-4, R-1, S-2
Petroleum fractions serve specific industrial and domestic applications based on volatility. LPG provides cooking fuel for homes and commercial facilities. Petrol powers light motor vehicles like cars and motorcycles. Diesel fuels heavy transport vehicles like trucks and buses. Bitumen is a thick, sticky residue used for road surfacing.

69. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Compressed Natural Gas consists mostly of methane, a small gaseous hydrocarbon that mixes thoroughly with air. This results in efficient, near complete combustion inside engine cylinders. Because it produces negligible unburnt carbon particles and low toxic gas emissions compared to liquid fuels, CNG is widely adopted as a clean transport fuel.

70. (D) Carbon dioxide and water
Complete combustion occurs when hydrocarbon fuels burn in the presence of an abundant supply of oxygen gas. During this oxidation process, all carbon atoms in the hydrocarbon fuel are fully oxidized to form carbon dioxide gas, while all hydrogen atoms are oxidized to yield water vapor, releasing heat energy.

71. (B) Carbon monoxide
When carbon based fuels undergo combustion in a limited or insufficient supply of oxygen, incomplete oxidation takes place. Rather than forming harmless carbon dioxide, incomplete combustion generates unburnt carbon soot and carbon monoxide gas, CO. Carbon monoxide is an odorless, colorless, and extremely toxic gas that poses severe health hazards.

72. (C) It binds to hemoglobin, preventing oxygen transport.
Inhaled carbon monoxide binds to hemoglobin in red blood cells with an affinity roughly two hundred times greater than oxygen, forming carboxyhemoglobin. This extremely stable complex prevents oxygen from binding to hemoglobin and severely impairs oxygen transport to bodily tissues and vital organs, causing hypoxia and potentially fatal asphyxiation.

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73. (D) Carbon dioxide
The combustion of fossil fuels releases significant quantities of carbon dioxide into Earth's atmosphere. As a potent greenhouse gas, carbon dioxide absorbs outgoing infrared radiation emitted from Earth's surface and traps heat within the troposphere, driving the enhanced greenhouse effect, changing climate patterns, and raising global average temperatures.

74. (A) Recent biological matter or biomass
Biofuels are renewable energy sources produced from contemporary biological materials, known as biomass, such as agricultural crops, plant oils, animal fats, and organic waste. Unlike fossil fuels, which require millions of years of geological formation underground, biofuels are derived from recently living organic matter harvested through sustainable agricultural cycles.

75. (B) Ethanol
Bioethanol, produced by fermenting sugar and starch components of plant crops, is the main liquid biofuel blended with commercial petrol in India. National biofuel policies promote ethanol blended petrol to reduce crude oil import dependency, enhance fuel combustion efficiency, and decrease harmful tailpipe exhaust emissions like carbon monoxide.

76. (B) Jatropha (Ratanjot)
Jatropha curcas, locally known as Ratanjot, is a hardy, drought resistant non-edible plant species promoted extensively in arid and semi-arid regions like Rajasthan. The seeds of Jatropha contain high oil content that can be extracted and processed via transesterification into high quality biodiesel, suitable for blending with fossil diesel.

77. (A) Edible food crops rich in starch or sugars
First generation biofuels are manufactured using conventional conversion technologies directly from edible agricultural food crops. Raw materials typically include sugar rich crops like sugarcane and sugar beet, or starch heavy food crops such as corn, wheat, and vegetable oils. This reliance on edible feedstocks can spark debate over food security.

78. (B) I and II only
Biofuels are renewable energy resources derived from recently harvested organic biomass rather than deep underground fossil fuel reservoirs. Blending bioethanol into petrol improves oxygen content during combustion, reducing carbon monoxide exhaust emissions. Because biofuels originate from surface plant matter, claiming they are extracted from deep oil wells is false.

79. (D) Petrol and ethanol
Gasohol is an alternative motor fuel blend consisting of gasoline, also known as petrol, combined with ethyl alcohol, or ethanol. Typically formulated with ten to twenty percent bioethanol mixed into unleaded petrol, gasohol serves as a cleaner burning fuel that reduces fossil fuel consumption and lowers harmful vehicle exhaust emissions.

80. (C) Carbon cycle
The carbon cycle is a major biogeochemical cycle describing the continuous exchange and movement of carbon across Earth's reservoirs. Carbon cycles continuously between the atmosphere, terrestrial biosphere, hydrosphere, and lithosphere through combined biological, physical, geological, and chemical processes like photosynthesis, respiration, decomposition, ocean dissolution, and volcanic emissions.

81. (B) Photosynthesis
Photosynthesis is the primary biological pathway responsible for extracting carbon dioxide from the atmosphere. Green plants, algae, and photosynthetic bacteria absorb atmospheric carbon dioxide and utilize sunlight energy to synthesize organic carbon molecules, converting radiant solar energy into chemical energy while releasing oxygen gas back into the air.

82. (D) Respiration by plants and animals
Respiration is a vital metabolic process in living organisms that oxidizes organic nutrients to produce biological energy. During cellular respiration, plants, animals, and microorganisms consume oxygen and break down carbohydrates, releasing carbon dioxide gas back into the surrounding atmosphere as a metabolic byproduct, completing the biological carbon loop.

83. (A) Lower melting and boiling points
Organic compounds generally consist of discrete covalent molecules held together by weak intermolecular attractive forces, such as van der Waals interactions. In contrast, inorganic compounds frequently form rigid ionic crystal lattices held by powerful electrostatic bonds. Consequently, organic compounds typically display much lower melting and boiling points.

84. (C) Weak intermolecular forces between molecules
In covalent organic compounds, atoms within a molecule are joined by strong covalent bonds, but the forces attracting adjacent molecules to one another are relatively weak van der Waals or dipole forces. Because breaking these weak intermolecular forces requires minimal heat energy, organic substances exhibit low melting and boiling points.

85. (A) Poor conductors of electricity
Electrical conductivity requires the presence and movement of charged particles, such as free electrons or mobile ions. Covalent organic compounds consist of neutral molecules held together by shared electron pairs and lack mobile charged particles. Consequently, most pure covalent organic substances act as non-electrolytes and poor conductors of electricity.

86. (D) -ene
According to IUPAC nomenclature guidelines, the primary suffix of an open chain hydrocarbon indicates the presence and nature of carbon to carbon multiple bonds. Saturated hydrocarbons

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containing single bonds end with the suffix -ane, while hydrocarbons containing one or more carbon to carbon double bonds are classified as alkenes and end with -ene.

87. (A) P-2, Q-1, R-4, S-3
Historical chemical milestones reflect fundamental scientific discoveries. J.J. Berzelius proposed the Vital Force Theory regarding organic synthesis. Friedrich Wöhler successfully synthesized organic urea disproving vitalism. Architectural geodesic domes inspired the unique spherical shape of Buckminsterfullerene molecules. Sumio Iijima discovered carbon nanotubes, significantly advancing modern nanoscience and structural carbon allotrope chemistry.

88. (C) $-CH_2$
A homologous series consists of structurally similar organic compounds sharing the same functional group and chemical reactivity. Any two adjacent, successive members within a given homologous series differ in their molecular formulas by exactly one carbon atom and two hydrogen atoms, corresponding to a repeating methylene unit, $-CH_2-$.

89. (A) P-2, Q-1, R-4, S-3
Functional groups define organic chemical behavior and classify chemical families. The alcohol family is characterized by the polar hydroxyl group -OH. Aldehydes contain the terminal formyl group -CHO. Ketones feature an internal carbonyl group >C=O attached directly to two carbon atoms. Carboxylic acids possess the acidic carboxyl group -COOH.

90. (A) Ethanol
Ethanol, CH_3CH_2OH, is a versatile organic compound extensively used across major industries. It serves as an effective solvent for pharmaceuticals, cosmetics, and dyes, acts as the active antimicrobial agent in modern hand sanitizers, and constitutes the intoxicating ingredient present in all commercial alcoholic beverages produced via fermentation.

91. (C) Trichloromethane
Chloroform is a volatile, colorless liquid historically utilized as an inhalation anesthetic in medical surgery. Its chemical formula is $CHCl_3$, consisting of a single central carbon atom bonded to one hydrogen atom and three chlorine atoms. Under systematic IUPAC nomenclature, chloroform is correctly designated as trichloromethane.

92. (B) Tetrafluoroethylene
Teflon, chemically known as polytetrafluoroethylene or PTFE, is a synthetic fluoropolymer valued for its chemical inertness, high thermal resistance, and low friction coefficient. It is produced by polymerizing the gaseous monomer tetrafluoroethylene, $CF_2=CF_2$, forming long chain polymer molecules widely utilized as non-stick coatings for cookware.

93. (A) Ethene
Methane, ethane, and propane are all saturated hydrocarbons belonging to the alkane homologous series, featuring exclusively single covalent bonds between atoms. In contrast, ethene is an unsaturated hydrocarbon belonging to the alkene family, containing a carbon to carbon double bond, making it structurally distinct from the other saturated alkanes.

94. (C) Tetravalency
Tetravalency refers to the state of having four valence electrons available for chemical bonding. A carbon atom possesses four valence electrons, enabling it to form four covalent bonds simultaneously with other carbon atoms or different elements, facilitating the synthesis of millions of distinct and stable organic molecules.

95. (D) The sharing of electron pairs between two atoms
A covalent bond is a fundamental chemical bond formed when two non-metallic atoms share one or more pairs of valence electrons between them. This mutual electron sharing enables each participating atom to attain a stable, noble gas valence electron configuration, holding the bonded atomic nuclei together within a molecule.

96. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Carbon monoxide gas poses extreme lethal risks in enclosed environments. When inhaled, carbon monoxide binds to hemoglobin in the bloodstream far more strongly than oxygen, forming stable carboxyhemoglobin. This blocks normal oxygen binding and severely starves body tissues of oxygen, leading quickly to asphyxiation, tissue hypoxia, and death.

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97. (C) Prop - 4 carbons
In standard IUPAC organic nomenclature, root prefixes systematically indicate carbon chain lengths. Meth- represents one carbon atom, eth- represents two carbon atoms, prop- represents three carbon atoms, and but- represents four carbon atoms. Assigning prop- to four carbon atoms is incorrect, as prop- specifically denotes three carbon atoms.

98. (A) 2, 1, 4, 3
The biological and geological carbon cycle follows a clear sequence. Carbon dioxide present in the atmosphere is absorbed by plants during photosynthesis. Over millions of years, dead plant matter undergoes underground fossilization to form fossil fuels. Finally, the combustion of these fossil fuels releases carbon dioxide back into the atmosphere.

99. (B) 4
Carbon has an atomic number of six, giving it a ground-state electronic configuration of two electrons in the inner shell and four in the valence shell. To attain a stable octet configuration resembling neon, carbon requires four additional electrons, which it achieves by sharing four electrons to form covalent bonds.

100. (B) Two pairs
A double covalent bond forms when two adjacent atoms share two pairs of electrons between them, involving four electrons in total. In ethene, $H_2C{=}CH_2$, the two carbon atoms share exactly two pairs of valence electrons to construct the double bond, leaving two remaining valence electrons per carbon to bond with hydrogen.

101. (A) Quartz
Diamond, graphite, and coal represent elementary or carbonaceous forms of carbon, with diamond and graphite being pure crystalline allotropes. Quartz, in contrast, is a mineral composed exclusively of silicon dioxide, SiO_2, featuring a crystalline network of silicon and oxygen atoms, making it completely non-carbonaceous in chemical composition.

102. (D) Structural isomers
n-Pentane, isopentane, and neopentane share the identical molecular formula C_5H_{12} but feature different arrangements of their carbon skeletons. n-Pentane is a straight chain, isopentane contains one methyl branch, and neopentane features two methyl branches. Organic compounds with identical formulas but distinct structural bonding arrangements are structural isomers.

103. (B) Alkenes
Cycloalkanes are saturated cyclic hydrocarbons containing a single ring structure. Forming a closed ring reduces the total hydrogen count by two compared to open chain alkanes, giving cycloalkanes the general molecular formula C_nH_{2n}. This mathematical formula is identical to the general formula for acyclic open chain alkenes containing one double bond.

104. (B) 6 carbon atoms and 6 hydrogen atoms
Benzene is a planar cyclic aromatic hydrocarbon with the molecular formula C_6H_6. Its molecular structure consists of a regular hexagonal ring formed by six carbon atoms, with one hydrogen atom covalently bonded to each carbon atom. Delocalized pi electrons circulate above and below this six carbon, six hydrogen planar ring system.

105. (D) Methane
Methane, CH_4, is an odorless, highly flammable gas produced naturally during anaerobic microbial decomposition of organic plant matter in oxygen deficient environments like marshes, swamps, and rice paddies. Due to its characteristic generation and evolution in these wetland ecosystems, methane is commonly referred to in environmental chemistry as marsh gas.

106. (A) Yellow, sooty flame
Unsaturated hydrocarbons, such as alkenes and alkynes, possess a higher carbon to hydrogen ratio than saturated alkanes. When burned in standard air, incomplete combustion occurs because ambient air cannot supply oxygen fast enough to fully oxidize all carbon. Unburnt carbon particles become incandescent in the flame, producing a smoky, yellow, sooty flame.

107. (B) Catalyst and dehydrating agent
During esterification, a carboxylic acid reacts with an alcohol to yield an ester and water. Concentrated sulfuric acid is added to serve a dual function: it acts as an acid catalyst to accelerate the reaction rate and acts as a dehydrating agent by absorbing water, shifting equilibrium toward maximum ester production.

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108. (A) P-4, Q-3, R-2, S-1
Common everyday chemical names match specific IUPAC organic compounds. Vinegar contains ethanoic acid as its active acidic ingredient. Grain alcohol produced through yeast fermentation is ethanol. Wood spirit historically produced through wood distillation is methanol. Marsh gas evolved naturally from anaerobic decay in wetland environments is methane gas.

109. (B) II and III only
Carbon has an atomic number of six and is situated in Group 14 of the modern periodic table. Because gaining or losing four electrons requires high energy, carbon forms covalent bonds rather than ionic bonds in almost all its compounds. Thus, claims that carbon predominantly forms ionic compounds are incorrect.

110. (C) It contains free electrons that conduct electricity
In graphite, each carbon atom undergoes sp2 hybridization, forming three covalent bonds within planar hexagonal sheets. The fourth valence electron occupies an unhybridized p orbital and becomes delocalized across the sheet layer. These delocalized, mobile pi electrons allow graphite to conduct electricity efficiently along its two-dimensional planes.

111. (A) P-3, Q-1, R-2, S-1
Hydrocarbon families follow specific general formulas matching their bonding and ring structures. Open chain saturated alkanes follow C_nH_{2n+2}. Open chain alkenes with one double bond follow C_nH_2n. Unsaturated alkynes with one triple bond follow C_nH_{2n-2}. Cycloalkanes containing a single saturated carbon ring also conform to the general formula C_nH_2n.

112. (C) Carbon
Organic chemistry is defined fundamentally as the study of carbon compounds. While elements like hydrogen, oxygen, nitrogen, and sulfur frequently occur in various organic molecules, carbon is the essential defining element present in every organic compound, forming the core structural backbone through its unique catenation and covalent bonding properties.

113. (B) Vinyl chloride (Chloroethene)
Polyvinyl chloride, commonly known as PVC, is a widely used synthetic thermoplastic polymer employed in plumbing pipes, cable insulation, and construction materials. It is manufactured through addition polymerization of the monomer vinyl chloride, systematically named chloroethene, CH_2=CHCl, forming repeating structural units along the polymer carbon chain.

114. (B) Methane < Ethane < Propane < Butane
As the molecular mass of straight chain alkanes increases within a homologous series, the surface area of the molecules grows larger. This increases the strength of intermolecular van der Waals dispersion forces holding adjacent molecules together. Consequently, boiling points increase progressively from methane to ethane, propane, and butane.

115. (A) C_3H_4
Alkynes are unsaturated open chain hydrocarbons containing a carbon to carbon triple bond, conforming strictly to the general formula CnH_{2n-2}. For a three carbon alkyne where n equals three, substituting into the formula gives two times three minus two, which equals four hydrogen atoms. Thus, C_3H_4 represents propyne, a true alkyne.

116. (A) 2, 4, 1, 3
During petroleum fractional distillation, fractions separate according to boiling point ranges. Low molecular weight gaseous fractions evaporate first at low temperatures, followed by progressively heavier liquid cuts. Thus, petroleum gas distills lowest, followed by petrol, diesel oil, and finally heavy lubricating oil, which possesses the highest boiling point range.

117. (A) Ethene
Heating ethanol with excess concentrated sulfuric acid at 443 K causes intramolecular dehydration. Concentrated sulfuric acid acts as a powerful dehydrating agent, abstracting a molecule of water from ethanol. Removing a hydrogen atom and hydroxyl group from adjacent carbon atoms creates a carbon to carbon double bond, yielding ethene gas.

118. (D) Catenation and tetravalency
Carbon forms millions of distinct organic compounds due to two unique properties: catenation and tetravalency. Catenation allows carbon atoms to link together into stable, extended chains, branches, and rings. Tetravalency enables each carbon atom to form four strong covalent bonds with other atoms,

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providing immense structural versatility across organic molecules.

119. (B) Release of greenhouse gases causing global warming

Large scale combustion of fossil hydrocarbon fuels releases vast quantities of carbon dioxide into the atmosphere. As a major greenhouse gas, carbon dioxide traps thermal radiation, intensifying Earth's natural greenhouse effect. This continuous accumulation drives global warming, altering climate patterns, causing ocean acidification, and threatening worldwide ecological balance.

120. (C) Derived from non-food biomass like agricultural waste

Second generation biofuels offer environmental and social advantages over first generation fuels by utilizing non-food biomass sources. Raw materials include agricultural residues, forestry waste, straw, and dedicated energy crops rather than edible food crops. This prevents competition with food supplies while converting agricultural waste into clean, sustainable liquid transportation fuels.

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CHAPTER 04

Industrial Carbon Compounds, Freon and CNG

1. Which of the following best describes the chemical composition of Freon?
(A) Hydrocarbons containing sulfur
(B) Chlorofluorocarbons
(C) Oxides of nitrogen
(D) Polycyclic aromatic hydrocarbons

2. What is the chemical formula of Freon-12, the most commonly used refrigerant in older air conditioners?
(A) $CFCl_3$
(B) $C_2F_4Cl_2$
(C) CH_4
(D) CF_2Cl_2

3. What is the primary constituent of Compressed Natural Gas (CNG)?
(A) Methane
(B) Propane
(C) Butane
(D) Ethane

4. In which layer of the atmosphere is the protective ozone layer located?
(A) Troposphere
(B) Mesosphere
(C) Stratosphere
(D) Thermosphere

5. Which of the following is the main reason for compressing natural gas to high pressures (200-250 bar) to form CNG?
(A) To reduce its volume for transport
(B) To raise its combustion temperature
(C) To decrease its density for flight
(D) To convert it into a solid matrix

6. Liquefied Petroleum Gas (LPG) primarily consists of a mixture of which two gases?
(A) Methane and Ethane
(B) Ethylene and Propylene
(C) Carbon dioxide and Carbon monoxide
(D) Propane and Butane

7. Which element present in chlorofluorocarbons (CFCs) is primarily responsible for the depletion of the ozone layer?
(A) Carbon
(B) Chlorine
(C) Fluorine
(D) Hydrogen

8. Which international treaty was specifically designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion?
(A) Kyoto Protocol
(B) Paris Agreement
(C) Montreal Protocol
(D) Ramsar Convention

9. Why are Hydrofluorocarbons (HFCs) considered better alternatives to Chlorofluorocarbons (CFCs) for the ozone layer?
(A) HFCs are lighter than air.
(B) HFCs react with ozone to produce oxygen.
(C) HFCs are entirely non-greenhouse gases.
(D) HFCs do not contain chlorine atoms.

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): CNG is considered a safer fuel than LPG in case of a leak.
Reason (R): CNG is lighter than air and disperses rapidly upwards, while LPG is heavier than air and settles near the ground.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

11. Which of the following is NOT a characteristic of Freon?
(A) Odorless under ambient atmospheric conditions

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(B) Flammable and reactive at room temperature
(C) Non-toxic when released into open air spaces
(D) Possessing an exceptionally low boiling point

12. On which date is the International Day for the Preservation of the Ozone Layer (World Ozone Day) observed?
(A) 5th June
(B) 16th September
(C) 22nd April
(D) 1st December

13. Which unit is used to measure the thickness or concentration of ozone in the atmosphere?
(A) Dobson Unit
(B) Decibel
(C) Pascal
(D) Roentgen

14. What happens when a molecule of ozone (O_3) absorbs ultraviolet (UV) radiation in the stratosphere?
(A) It combines directly with another ozone molecule to form O_6 gas.
(B) It reacts with trace atmospheric gases to turn into carbon dioxide.
(C) It splits into an O_2 molecule and a free O atom.
(D) It absorbs stratospheric water vapor and condenses rapidly.

15. Match List I with List II.
List I: Substance
P. Freon-11
Q. Methane
R. Butane
S. Ethyl mercaptan
List II: Key Property/Use
1. Major component of LPG
2. Used as a refrigerant
3. Major component of CNG
4. Added to LPG for odor detection
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-1, R-3, S-4
(D) P-1, Q-2, R-4, S-3

16. What is the fundamental principle behind refrigeration technology?
(A) Condensation of a compressed gas rapidly absorbs surrounding thermal heat.
(B) Sublimation of a solid matrix releases significant thermal heat energy.
(C) Evaporation of a liquid absorbs heat to cause cooling.
(D) Heating a pressurized gas causes immediate thermal cooling effects.

17. Which of the following greenhouse gases is produced largely by agricultural practices such as paddy cultivation and the digestive processes of ruminant livestock?
(A) Chlorofluorocarbons
(B) Methane
(C) Nitrous oxide
(D) Sulfur dioxide

18. Why is CNG considered a "clean fuel" compared to traditional petrol or diesel?
(A) It possesses an exceptionally low calorific energy value per unit mass.
(B) It is extracted directly from atmospheric air without chemical processing.
(C) It absorbs all existing atmospheric greenhouse gases during combustion.
(D) It burns completely, producing negligible unburnt hydrocarbons.

19. What is the phenomenon called where certain gases in the Earth's atmosphere trap infrared radiation, leading to an increase in global temperatures?
(A) Greenhouse effect
(B) Ozone depletion
(C) Acid rain
(D) Eutrophication

20. Consider the following statements regarding the environmental benefits of CNG:
I. It produces significantly less carbon monoxide than petrol.
II. It emits higher levels of sulfur dioxide than diesel.
III. It does not contain lead.
Which of the above statements is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II, and III

21. Which gas is responsible for the majority of the natural greenhouse effect on Earth?
(A) Water vapor
(B) Carbon dioxide
(C) Methane
(D) Ozone

22. In the context of CFC nomenclature, what does Freon-11 stand for chemically?

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(A) CF_2Cl_2
(B) C_2F_4
(C) CH_3Cl
(D) $CFCl_3$

23. During aerosol spray usage, what is the role of Freon?
(A) It acts as the primary active chemical ingredient to eliminate pests.
(B) It functions as a propellant to expel can contents.
(C) It provides a pleasant aromatic fragrance to mask chemical odors.
(D) It slowly dissolves the protective inner metal lining over time.

24. What was the main observation that led to the discovery of the "Ozone Hole"?
(A) A severe thinning of the protective ozone layer over the Arctic region during summer months.
(B) The total and complete absence of stratospheric ozone over equatorial tropical regions.
(C) A drastic ozone reduction over Antarctica during polar spring.
(D) An unprecedented increase in ozone levels in the troposphere over industrial cities.

25. Select the correct order of the following greenhouse gases in terms of their typical contribution (from highest to lowest) to global warming:
(A) Methane > Carbon dioxide > CFCs > Nitrous oxide
(B) Carbon dioxide > Methane > CFCs > Nitrous oxide
(C) CFCs > Carbon dioxide > Nitrous oxide > Methane
(D) Nitrous oxide > Carbon dioxide > Methane > CFCs

26. Which of the following chemical bonds is broken by UV radiation in a CFC molecule to initiate ozone depletion?
(A) C-Cl bond
(B) C-F bond
(C) C-H bond
(D) C-C bond

27. What is the approximate percentage of methane in a standard sample of CNG?
(A) 20-30%
(B) 40-50%
(C) 60-70%
(D) 80-90%

28. Which of the following is an industrial use of natural gas besides being a fuel?
(A) Used as the primary essential raw material to manufacture industrial glass products.
(B) Used as a raw material for producing fertilizers.
(C) Used directly as a chemical agent to purify municipal drinking water supplies.
(D) Used as a high-viscosity heavy lubricant inside industrial machinery systems.

29. Identify the incorrect statement regarding LPG.
(A) It consists mainly of methane and ethane.
(B) It is significantly heavier than ambient atmospheric air.
(C) It is routinely stored under moderate pressure as a liquid.
(D) It possesses a remarkably high calorific energy value.

30. Match List I with List II.
List I: Process/Phenomenon
P. Acid Rain
Q. Ozone Depletion
R. Global Warming
S. Fuel Odorization
List II: Associated Chemical
1. Chlorofluorocarbon
2. Sulfur dioxide
3. Ethyl mercaptan
4. Carbon dioxide
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

31. Which of the following statements best describes the "Ozone Hole"?
(A) A physical rupture or vacuum hole in the atmosphere containing no air molecules.
(B) A specific zone located in the troposphere exhibiting excessive ozone pollution.
(C) An atmospheric region where CFCs have burned the ozone layer into soot particles.
(D) A stratospheric region with reduced ozone levels.

32. In the expansion of CNG use in India, which sector has primarily driven its adoption in major cities?
(A) Commercial aviation and air transport sector

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(B) International marine shipping and cargo vessels
(C) Public and private road transport
(D) Industrial thermal power generation plants

33. The Montreal Protocol was agreed upon in which year?
(A) 1972
(B) 1987
(C) 1997
(D) 2005

34. What is the primary environmental drawback of using HFCs (Hydrofluorocarbons) as an alternative to CFCs?
(A) They exhibit extreme biological toxicity to humans upon exposure.
(B) They react in the atmosphere to cause severe localized acid rain.
(C) They deplete the stratospheric ozone layer at faster rates than CFCs.
(D) They are potent greenhouse gases.

35. Find the odd one out with respect to types of fuel.
(A) Compressed Natural Gas
(B) Refined liquid petrol fuel
(C) Refined liquid diesel fuel
(D) Solid combustible mineral coal

36. Which of the following is NOT a consequence of global warming?
(A) Rising sea levels
(B) Increased frequency of extreme weather events
(C) Expansion of the ozone hole
(D) Melting of polar ice caps

37. What property of Freon made it highly suitable for early refrigeration systems?
(A) It easily changes state under pressure.
(B) It possesses an exceptionally high liquid boiling point.
(C) It acts as a highly corrosive liquid substance that cleans internal pipes.
(D) It conducts electrical current very efficiently within system circuits.

38. Which chemical is intentionally added to LPG cylinders to help detect gas leaks?
(A) Hydrogen sulfide
(B) Chloroform
(C) Methane
(D) Ethyl mercaptan

39. Natural gas is often found associated with which other natural resource during extraction?
(A) Subterranean coal mineral deposits
(B) Petroleum deposits
(C) Deep underground iron ore mines
(D) Sedimentary uranium ore deposits

40. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Chlorofluorocarbons (CFCs) are stable in the troposphere but break down in the stratosphere.
Reason (R): The stratosphere contains high-energy UV radiation which has enough energy to break the strong carbon-chlorine bonds in CFCs.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

41. Which physical state is CNG maintained in when stored in a typical vehicle cylinder?
(A) Solid
(B) Liquid
(C) Plasma
(D) Gas

42. In which of the following applications is CNG primarily utilized today?
(A) As an automotive fuel
(B) As an aerosol propellant
(C) As a refrigerant in air conditioners
(D) As a fire extinguishing agent

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43. Exposure to increased levels of UV-B radiation due to ozone depletion can directly cause which of the following health issues in humans?
(A) Chronic obstructive lung cancer
(B) Skin cancer and cataracts
(C) Mosquito-borne malaria infection
(D) Acute cardiovascular heart diseases

44. What is the main source of atmospheric pollution in industrial zones?
(A) Natural photosynthesis by green trees
(B) Fossil fuel combustion
(C) Incoming solar radiation beams
(D) Natural soil wind erosion processes

45. Match List I with List II.
List I: Greenhouse Gas
P. Carbon dioxide

Q. Methane
R. Nitrous oxide
S. CFCs

List II: Primary Anthropogenic Source

1. Refrigeration and aerosols
2. Fossil fuel combustion
3. Agricultural soils and fertilizers
4. Paddy fields and livestock

(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-1, R-2, S-4

46. What does the term "Global Warming Potential" (GWP) measure?
(A) The total net volumetric quantity of atmospheric gas emitted annually by an industrial facility.
(B) The precise rate of chemical speed at which a gas molecule depletes stratospheric ozone layer.
(C) Heat trapped by a gas relative to CO_2.
(D) The total quantity of thermal energy produced by burning a unit volume of clean fuel.

47. Which transition represents the shift towards sustainable energy sources in transport?
(A) Shifting from clean CNG fuel to conventional Diesel engines
(B) Shifting from modern Solar energy to traditional Coal power
(C) Shifting from LPG domestic gas to untreated Wood burning
(D) From Petrol to Electric vehicles

48. Identify the correct statement about the ozone layer.
(A) It is formed by the reaction of carbon dioxide and sunlight.
(B) It protects the Earth from harmful infrared radiation.
(C) It is primarily concentrated in the stratosphere.
(D) It is a major cause of acid rain.

49. Which of the following is an example of an alternative fuel?
(A) Petrol
(B) Biodiesel
(C) Kerosene
(D) Furnace oil

50. Consider the following statements regarding the health effects of Freon inhalation:
I. Inhalation of high concentrations can cause dizziness and asphyxiation.
II. It directly causes permanent genetic mutations in human lungs.
III. It can displace oxygen in enclosed spaces leading to suffocation.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

51. The calorific value of CNG is approximately:
(A) 20 - 25 kJ/g
(B) 30 - 35 kJ/g
(C) 50 - 55 kJ/g
(D) 100 - 150 kJ/g

52. Which of the following groups of elements make up chlorofluorocarbons?
(A) Carbon, Hydrogen, and Oxygen
(B) Calcium, Fluorine, Carbon
(C) Chlorine, Fluorine, Carbon
(D) Chlorine, Iron, Carbon

53. The process of converting natural gas into compressed natural gas involves:
(A) High pressure compression without liquefaction.
(B) Lowering the gas storage temperature down to absolute zero degrees.
(C) Boiling the gas at exceptionally high temperatures under pressure.
(D) Dissolving the gas completely into deep aqueous water reservoirs.

54. What is the impact of ozone depletion on marine ecosystems?
(A) It significantly increases the overall salt salinity levels of ocean water.
(B) It causes surface ocean water to freeze significantly faster in winter.
(C) It leads directly to the overpopulation of large predatory fish species.
(D) It destroys phytoplankton, disrupting food webs.

55. Arrange the following steps in the typical mechanism of ozone depletion by CFCs in the correct sequence:
I. A free chlorine atom reacts with an ozone molecule, forming chlorine monoxide and

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oxygen.
II. UV radiation breaks the carbon-chlorine bond in a CFC molecule.
III. A free chlorine atom is released into the stratosphere.
IV. Chlorine monoxide reacts with a free oxygen atom, releasing the chlorine atom to destroy more ozone.

Select the correct sequence:
(A) II, I, III, IV
(B) II, III, I, IV
(C) III, II, I, IV
(D) I, II, III, IV

56. Which of the following gases is NOT considered a greenhouse gas?
(A) Carbon dioxide
(B) Methane
(C) Nitrogen
(D) Water vapor

57. Compared to petrol and diesel vehicles, CNG vehicles emit significantly lower amounts of:
(A) Atmospheric oxygen gas emissions
(B) Pure inert diatomic nitrogen gas
(C) Ambient condensed water vapor steam drops
(D) Unburnt hydrocarbons and particulates

58. How does the combustion of CNG contribute to controlling air pollution?
(A) It emits minimal sulfur oxides and lower nitrogen oxides.
(B) It acts as a atmospheric chemical catalyst to break down existing urban smog.
(C) It continuously releases pure oxygen into the surrounding atmosphere during combustion.
(D) It completely neutralizes ambient atmospheric carbon dioxide gas upon reaction.

59. Which of the following is a vital precaution in the storage of CNG?
(A) It must always be kept at cryogenic temperatures of -196 °C inside open container units.
(B) Cylinders must withstand very high pressure.
(C) It must be stored thoroughly mixed with pure oxygen gas to remain stable.
(D) It requires specialized storage inside flexible high-density plastic bags.

60. Match List I with List II.
List I: Fuel
P. CNG
Q. LPG
R. Petrol
S. Coal
List II: Major Characteristic
1. Solid fossil fuel with high carbon emission
2. Liquid fuel used heavily in light motor vehicles
3. Gas compressed at high pressure for vehicles
4. Gas liquefied under moderate pressure for cooking

(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-4, R-2, S-3

61. What is meant by the term "Clean Fuel"?
(A) A fuel producing minimal emissions on burning.
(B) A fuel that is entirely transparent and clear in color prior to combustion.
(C) A fuel that has been thoroughly washed with liquid water before industrial use.
(D) A fuel that produces zero net energy output during chemical reactions.

62. Which atmospheric process naturally creates ozone in the stratosphere?
(A) Biological photosynthesis occurring in marine phytoplankton
(B) Explosive volcanic eruptions releasing trace atmospheric gases
(C) UV radiation action on oxygen molecules
(D) Frequent electrical lightning strikes within the lower troposphere

63. Why is carbon dioxide considered a major driver of climate change despite having a lower GWP than CFCs?
(A) Because it is exceptionally toxic to human pulmonary breathing systems.
(B) Because it directly breaks down and destroys the stratospheric ozone layer.
(C) Because it is much lighter than air and rapidly escapes into outer space.
(D) Because it is emitted in vastly larger quantities.

64. Identify the correct pair:
(A) Freon - Used in cooking
(B) CNG - Uncompressed methane
(C) LPG - Liquefied butane and propane
(D) Ozone - Greenhouse gas with no UV protection role

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65. What does the abbreviation 'CFC' stand for?
(A) Carbon Fluorine Chloride
(B) Chloro Fluoro Carbon
(C) Compressed Fuel Carbon
(D) Combustible Free Carbon

66. A typical CNG cylinder in a car operates at a pressure of around:
(A) 2 to 5 bar
(B) 20 to 25 bar
(C) 200 to 250 bar
(D) 1000 to 1200 bar

67. Which property makes Freon suitable for use as a propellant in aerosol sprays?
(A) Its volatility and pressure exertion capability.
(B) Its natural thermodynamic ability to burn very brightly during ignition.
(C) Its highly adhesive and sticky structural physical nature when compressed.
(D) Its exceptionally high chemical reactivity with aerosol metal cans over time.

68. The "greenhouse effect" is named so because the Earth's atmosphere behaves similarly to a greenhouse. A greenhouse primarily traps:
(A) High-frequency ultraviolet radiation
(B) Broad-spectrum visible sunlight
(C) Infrared thermal heat
(D) Penetrating atmospheric X-rays

69. Which of the following is a natural source of methane emissions?
(A) Wetlands and marshes
(B) Industrial refrigeration
(C) Volcanoes
(D) Solar flares

70. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The use of CNG in public transport buses has helped reduce urban air pollution in major cities.
Reason (R): CNG combustion produces fewer harmful pollutants like particulate matter and carbon monoxide compared to diesel.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

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71. One atom of chlorine released from a CFC molecule can destroy approximately how many ozone molecules?
(A) 10
(B) 100
(C) 1,000
(D) 100,000

72. Which of the following is a common method to control industrial emissions of particulate matter?
(A) Using chlorofluorocarbons
(B) Increasing the use of coal
(C) Installing electrostatic precipitators
(D) Releasing emissions directly into rivers

73. Which of the following is the most appropriate description of "Climate Change"?
(A) Immediate short-term day-to-day changes occurring in local ambient weather.
(B) The regular seasonal climate change transition taking place from summer to winter.
(C) The continuous daily fluctuations observed in atmospheric barometric pressure.
(D) Long-term shifts in temperatures and weather patterns.

74. Which natural resource is the primary source from which CNG is obtained?
(A) Natural gas deposits
(B) Underground coal mines exclusively
(C) Cryogenic atmospheric air separation units
(D) Anaerobic fermentation of organic biomass

75. Match List I with List II.
List I: Environmental Issue
P. Stratospheric Ozone Depletion
Q. Enhanced Greenhouse Effect
R. Indoor Air Pollution (from incomplete combustion)
S. Photochemical Smog (urban areas)
List II: Primary Associated Gas
1. Nitrogen oxides (NOx)
2. Chlorofluorocarbons (CFCs)
3. Carbon dioxide (CO_2)
4. Carbon monoxide (CO)
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-4, R-3, S-1

76. In an air conditioning unit, what happens to the Freon gas when it passes through the expansion valve?
(A) It undergoes rapid mechanical compression and heats up significantly.
(B) It expands rapidly, dropping in pressure and temperature.
(C) It undergoes a phase change and turns completely into solid ice.
(D) It chemically reacts with ambient oxygen to produce streams of cool air.

77. Which of the following statements about the ozone layer is incorrect?
(A) It is thickest near the equator and thinnest at the poles.
(B) It absorbs most of the sun's ultraviolet-B (UV-B) radiation.
(C) Its depletion has led to an increase in cataracts and skin cancer.
(D) It consists of molecules made of three oxygen atoms.

78. Which of the following alternative fuels is derived mainly from agricultural crops and organic waste, making it a sustainable energy source?
(A) Fossil natural gas
(B) Unrefined liquid petroleum
(C) Bio-CNG
(D) Liquefied Petroleum Gas (LPG)

79. What is the standard atmospheric pressure equivalent to 1 bar?
(A) 100,000 Pascals (100 kPa)
(B) 1,000 Pascals (1 kPa)
(C) 10 Pascals
(D) 1,000,000 Pascals

80. Consider the following statements about measures to control industrial emissions:
I. Switching from high-sulfur coal to natural gas reduces SO_2 emissions.
II. Scrubbers in smokestacks can remove acidic gases.
III. Increasing the height of chimneys completely eliminates total greenhouse gas emissions.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

81. The transition towards sustainable energy sources involves shifting from:
(A) Clean renewable resources to non-renewable fossil fuel resources
(B) Fossil fuels to renewable energy sources.
(C) Sustainable biofuels to heavy polluting mineral coal
(D) Compressed natural gas to traditional wood burning fuels

82. Which of the following is an exception to the ban on CFCs under the Montreal Protocol?
(A) General commercial use inside automotive mobile air conditioning units.
(B) Widespread everyday use inside residential household refrigerators.
(C) Routine industrial use in cosmetic aerosol spray manufacturing.
(D) Essential medical inhalers lacking suitable substitutes.

83. Why is CNG transportation through pipelines considered efficient?
(A) It eliminates road transport and lowers emissions.
(B) Gas moving through pipelines requires zero mechanical pumping pressure.
(C) The pipeline system automatically converts gas into a liquid state during transit.
(D) It completely prevents stored gas from ever catching fire or burning.

84. Which of the following is the most significant advantage of natural gas over coal in power generation?
(A) It generates vastly greater quantities of solid toxic ash waste products.
(B) It is significantly harder and more dangerous to transport over long distances.
(C) It emits half as much CO_2 per unit energy.
(D) It requires substantially larger land storage areas for power plants.

85. Select the correct sequence of the atmospheric layers starting from the Earth's surface upwards:
(A) Stratosphere, Troposphere, Mesosphere, Thermosphere
(B) Troposphere, Stratosphere, Mesosphere, Thermosphere
(C) Mesosphere, Troposphere, Stratosphere, Thermosphere
(D) Troposphere, Mesosphere, Stratosphere, Thermosphere

86. Which chemical property of CFCs contributes most to their role in ozone depletion?

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(A) They are exceptionally highly soluble when exposed to atmospheric water droplets.
(B) They possess an extraordinarily high flammability rate in normal oxygen conditions.
(C) They easily and rapidly break down into harmless components within the troposphere.
(D) Unreactivity in lower air lets them reach the stratosphere.

87. What is the major reason for retrofitting old vehicles with CNG kits?
(A) To significantly increase the overall maximum top speed of the vehicle.
(B) To meet emission norms and cut fuel costs.
(C) To substantially expand available internal boot storage space in cars.
(D) To intentionally make the vehicle engine sound much louder during operation.

88. When distinguishing between CNG and LPG, which statement is true?
(A) CNG is supplied in liquid form, LPG in gaseous form.
(B) LPG primarily contains methane, whereas CNG contains butane.
(C) CNG is stored at much higher pressure than LPG.
(D) CNG is heavier than air, while LPG is lighter.

89. Which of the following is NOT an industrial application of natural gas?
(A) High-volume industrial production of ammonia for chemical fertilizers
(B) Primary operational fuel for high-capacity industrial boilers and furnaces
(C) Commercial large-scale production of pure hydrogen gas fuel
(D) Ingredient in concrete cement mixing.

90. Match List I with List II.
List I: Term
P. ODP
Q. GWP
R. CNG
S. LPG
List II: Definition
1. A measure of how much heat a greenhouse gas traps
2. Compressed gas primarily used in vehicles
3. A measure of a substance's potential to destroy the ozone layer
4. Liquefied gas widely used for domestic cooking

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-3, S-1

91. The gradual thinning of Earth's ozone layer observed predominantly in the late 20th century is largely attributed to the release of:
(A) Carbon dioxide gas
(B) Chlorofluorocarbons
(C) Atmospheric argon gas
(D) Diatomic oxygen gas

92. Which gas is responsible for the distinct pungent smell sometimes noticed near a leaking LPG cylinder?
(A) Liquefied butane gas
(B) Ethyl mercaptan
(C) Liquefied propane gas
(D) Compressed methane gas

93. What is the main reason why Methane is a potent greenhouse gas?
(A) It traps Earth's infrared heat far more efficiently than CO_2.
(B) It absorbs incoming high-energy ultraviolet sunlight very effectively.
(C) It reacts with atmospheric oxygen to release immense thermal heat energy.
(D) It forms dense reflective cloud layers that block incoming sunlight.

94. Identify the incorrect statement concerning Freon as a refrigerant.
(A) Freons possess exceptionally low biological human toxicity levels.
(B) Freons are generally non-flammable under normal pressure conditions.
(C) High chemical reactivity with cooling metals.
(D) Freons can easily be liquefied when placed under moderate pressure.

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95. Arrange the following stages of the CNG supply chain in the correct order:
I. Dispensing into vehicle cylinders at fuel stations
II. Compression to 200-250 bar
III. Extraction from natural gas wells
IV. Purification and removal of impurities like water and sulfur
Select the correct sequence:
(A) III, II, IV, I
(B) III, IV, II, I

(C) IV, III, I, II
(D) III, IV, I, II

96. What is the primary difference in the chemical composition between CNG and LPG?
(A) CNG contains primarily heavy butane, while LPG consists almost entirely of pure methane gas.
(B) CNG is a purely organic hydrocarbon, while LPG is classified as an inorganic gas compound.
(C) CNG is mostly methane, whereas LPG is propane and butane.
(D) CNG inherently contains active sulfur additives, whereas refined LPG contains no sulfur.

97. Which of the following elements is absent in Hydrofluorocarbons (HFCs), making them ozone-friendly?
(A) Carbon
(B) Chlorine
(C) Fluorine
(D) Hydrogen

98. Which of the following is a direct health consequence of exposure to high levels of greenhouse gases and associated air pollutants in urban areas?
(A) Rapidly increased clinical incidence of dermal skin cancer
(B) Sudden and immediate severe scalp hair loss symptoms
(C) Significantly increased immune resistance to viral lung infections
(D) Worsening of respiratory diseases like asthma.

99. The "Kigali Amendment" to the Montreal Protocol aims to phase down the use of which group of chemicals due to their high global warming potential?
(A) HFCs
(B) CFCs
(C) Halons
(D) Methyl bromide

100. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Carbon dioxide (CO_2) is considered the most significant anthropogenic greenhouse gas.
Reason (R): CO_2 has the highest Global Warming Potential (GWP) among all greenhouse gases on a per-molecule basis.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

101. Which of the following practices does NOT contribute to the expansion of atmospheric pollution?
(A) Afforestation and planting trees
(B) Burning of agricultural residue (stubble burning)
(C) Industrial emissions without filtration
(D) Increased vehicular traffic relying on fossil fuels

102. What type of chemical reaction generally takes place when CNG is used as a fuel in a vehicle engine?
(A) Endothermic chemical addition reaction
(B) Single chemical displacement reaction
(C) Double ionic decomposition reaction
(D) Exothermic combustion

103. Which is the most appropriate statement regarding the use of Freon in modern refrigerators?
(A) It remains currently the most widely used household refrigerant globally.
(B) It has been phased out due to ozone depletion.
(C) It is continuously mixed with purified water to improve cooling efficiency.
(D) It is exclusively used inside highly advanced industrial freezing units today.

104. Find the odd one out based on the state of the fuel at standard storage conditions for transport vehicles:
(A) Refined liquid petrol fuel
(B) Refined liquid diesel fuel
(C) Compressed Natural Gas
(D) Liquid Petroleum Gas (LPG)

105. Match List I with List II.
List I: Chemical Formula
P. CH_4
Q. O_3
R. CF_2Cl_2
S. C_4H_{10}
List II: Common Name

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1. Butane
2. Methane
3. Freon-12
4. Ozone

(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-3, R-4, S-1
(D) P-1, Q-4, R-3, S-2

106. The depletion of the ozone layer was most dramatically observed over which geographical region?
(A) Antarctica
(B) The Sahara Desert
(C) The Amazon Rainforest
(D) The Arctic

107. Which of the following represents the correct balanced chemical equation for the complete combustion of methane (the main component of CNG)?
(A) $CH_4 + O_2 \rightarrow CO_2 + H_2O$
(B) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
(C) $2CH_4 + O_2 \rightarrow 2CO + 4H_2$
(D) $CH_4 + O_2 \rightarrow C + 2H_2O$

108. Why is there a need to find alternatives to HFCs in refrigeration?
(A) Because they still continue to deplete the stratospheric ozone layer significantly.
(B) Because they are potent greenhouse gases.
(C) Because they are dangerously unstable, highly flammable, and explosive.
(D) Because they do not possess adequate thermodynamic properties for cooling units.

109. Which sector is typically the largest consumer of natural gas for industrial purposes?
(A) Fertilizer production
(B) Textile industry
(C) Pharmaceutical manufacturing
(D) Paper and pulp industry

110. Consider the following statements regarding the role of alternative fuels in environmental protection:
I. Alternative fuels like bio-CNG reduce dependency on imported crude oil.
II. They generally have a lower carbon footprint compared to traditional fossil fuels.
III. They always produce zero emissions under all circumstances.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

111. What is the primary purpose of a catalytic converter in a vehicle?
(A) To significantly increase the overall operational fuel efficiency of internal combustion engines.
(B) To mechanically compress natural gas fuel before it enters the combustion chamber of the engine.
(C) To continuously cool down internal engine operational temperatures during heavy driving conditions.
(D) To convert toxic exhaust gases into CO_2 and water.

112. In the context of global warming, what is the meaning of the term "Carbon Footprint"?
(A) The physical rubber tire mark left by a heavy transport vehicle on a paved road surface.
(B) The specific percentage amount of chemical carbon present within a refined fossil fuel.
(C) Total greenhouse gases caused by human actions.
(D) The physical soot particulate residue deposited on plant leaves located near industries.

113. Which characteristic of CNG makes it relatively safe during a leakage in an open space?
(A) Its extraordinarily low thermal ignition temperature threshold in open spaces.
(B) It is lighter than air and dissipates quickly.
(C) Its high physical vapor density which forces it to remain close to ground surfaces.
(D) It immediately freezes and solidifies into crystals upon direct contact with open air.

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114. The Montreal Protocol is often considered one of the most successful international environmental agreements because:
(A) It successfully stopped all aspects of worldwide global warming and climate change completely.
(B) It successfully eliminated all existing forms of industrial and vehicular air pollution in cities.
(C) It completely replaced all global fossil fuels with clean renewable wind and solar energy systems.
(D) It phased out ozone-depleting substances, aiding recovery.

115. Match List I with List II.

List I: Refrigerant Generation

P. 1st Generation Refrigerants (historical)

Q. 2nd Generation (CFCs)

R. 3rd Generation (HFCs)

S. 4th Generation (HFOs/Natural)

List II: Example/Characteristic

1. Low ODP, High GWP (e.g., R-134a)
2. Zero ODP, Low GWP (e.g., Propane, CO_2)
3. Toxic, flammable (e.g., Ammonia, SO_2)
4. High ODP, High GWP (e.g., Freon-12)

(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

116. Which of the following is an everyday use of Freon before it was banned?

(A) Used directly as a combustible fuel source for domestic cooking stoves.
(B) Used as a chemical solvent agent to purify municipal drinking water supplies.
(C) Used as a coolant in refrigerators and car ACs.
(D) Used directly as an essential chemical fertilizer in agricultural farming.

117. How does the expansion of CNG usage in public transport contribute to the economy?

(A) It builds infrastructure and cuts oil import bills.
(B) It drastically increases the overall daily operational cost of public municipal transport.
(C) It forces national government authorities to immediately ban all other private motor vehicles.
(D) It rapidly reduces the overall mechanical operational lifespan of vehicle engines by half.

118. Which of the following is a primary measure to control industrial emissions at the source?

(A) Building taller residential buildings near factories.
(B) Releasing waste gases exclusively during the night.
(C) Increasing the production rate to minimize waste time.
(D) Using cleaner fuels like natural gas instead of coal.

119. What is a key disadvantage of natural gas when compared to liquid fuels like petrol or diesel?

(A) It produces significantly greater quantities of dark carbon soot when burnt in engines.
(B) It requires large, heavy, pressurized storage tanks.
(C) It is significantly more complex and financially expensive to refine at processing plants.
(D) It inherently possesses a very unpleasant natural chemical odor that cannot be masked.

120. Consider the following statements regarding the differences between CNG and LPG:

I. CNG is stored as a gas under high pressure, while LPG is stored as a liquid under moderate pressure.
II. CNG mainly contains methane, whereas LPG mainly contains propane and butane.
III. CNG has a higher calorific value per kilogram than LPG.

Which of the above statements is/are correct?

(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

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ANSWERS

1. (B) Chlorofluorocarbons
Freon is a brand name for aliphatic organic compounds containing carbon, fluorine, and chlorine, collectively known as chlorofluorocarbons. These volatile halogenated hydrocarbons possess high thermodynamic stability, low toxicity, and non-flammable characteristics. Historically, they were widely utilized as refrigerants in cooling units, aerosol propellants in cans, and blowing agents across industrial applications worldwide.

2. (D) CF_2Cl_2
Freon-12 is chemically known as dichlorodifluoromethane and has the molecular formula CF_2Cl_2. It consists of one carbon atom bonded to two fluorine atoms and two chlorine atoms. Due to its stable chemical structure and favorable thermodynamic boiling properties, it was extensively employed as a primary refrigerant in older residential and automotive cooling systems.

3. (A) Methane
Methane is the primary constituent of compressed natural gas, typically making up eighty to ninety-five percent of its overall volume. This light hydrocarbon gas burns cleanly in combustion engines, releasing significantly fewer toxic pollutants than conventional liquid fossil fuels. Its simple molecular structure consists of one central carbon atom surrounded by four hydrogen atoms.

4. (C) Stratosphere
The protective ozone layer is located in the stratospheric layer of Earth's atmosphere, situated approximately fifteen to thirty-five kilometers above the terrestrial surface. Within this altitude zone, triatomic oxygen molecules absorb harmful solar ultraviolet radiation. This stratospheric absorption process shields living organisms on the Earth's surface from biological damage caused by intense ultraviolet rays.

5. (A) To reduce its volume for transport
Natural gas is compressed to high pressures ranging between two hundred and two hundred fifty bar to dramatically decrease its physical volumetric space. Compression allows a larger mass of gaseous fuel to be stored inside vehicle storage tanks efficiently. This mechanical reduction in volume makes gaseous fuel storage practical for transport and vehicular mobility.

6. (D) Propane and Butane
Liquefied petroleum gas is a flammable mixture composed primarily of propane and butane hydrocarbon molecules derived from crude oil refining and natural gas processing. Under moderate mechanical pressure, these gases readily convert into a liquid state for storage. This liquid conversion allows convenient, safe containment in transportable steel cylinders for cooking and heating.

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7. (B) Chlorine
Chlorine atoms present within chlorofluorocarbon molecules are the primary agents responsible for stratospheric ozone destruction. When high-energy solar ultraviolet radiation breaks the carbon-chlorine bond in the upper atmosphere, free chlorine radicals are released. A single chlorine radical acts as a catalytic agent, destroying thousands of stratospheric ozone molecules before becoming inactive.

8. (C) Montreal Protocol
The Montreal Protocol is an international environmental treaty adopted in 1987 to safeguard the stratospheric ozone layer. It regulates the production and global consumption of ozone-depleting substances, including chlorofluorocarbons and halons. The treaty has successfully phased out numerous harmful industrial chemicals worldwide, allowing the Earth's damaged stratospheric ozone layer to recover over time.

9. (D) HFCs do not contain chlorine atoms.
Hydrofluorocarbons are considered ozone-friendly alternatives to chlorofluorocarbons because their chemical structure lacks chlorine atoms entirely. Without chlorine, these synthetic chemical compounds cannot form catalytic chlorine free radicals when exposed to solar ultraviolet radiation in the upper atmosphere. Consequently, hydrofluorocarbons exert zero

ozone depletion potential on the Earth's protective stratospheric ozone layer.

10. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Compressed natural gas consists mainly of methane, which is lighter than atmospheric air and disperses rapidly upward during a leak, preventing localized concentration. Conversely, liquefied petroleum gas consists of heavier hydrocarbons that settle near ground level, creating persistent explosive hazards. Therefore, the physical density difference directly explains why compressed natural gas is safer.

11. (B) Flammable and reactive at room temperature
Freon compounds are characteristically non-flammable, non-reactive, and exceptionally stable under ambient atmospheric room temperature conditions. Their lack of chemical reactivity and non-combustible nature made them extremely popular historically for consumer appliances like refrigerators. Stating that Freon is flammable and reactive at room temperature is incorrect, as these gases exhibit strong chemical inertness.

12. (B) 16th September
World Ozone Day is celebrated annually on the sixteenth of September to commemorate the signing of the Montreal Protocol in 1987. Designated by the United Nations General Assembly, this international observance raises global public awareness about stratospheric ozone layer depletion and highlights collective environmental efforts required to phase out harmful chemical substances.

13. (A) Dobson Unit
The Dobson Unit is the standard measurement unit used globally to quantify the total column amount or thickness of atmospheric ozone. One Dobson Unit represents a theoretical layer of pure ozone gas zero point zero one millimeters thick at standard temperature and atmospheric pressure. Higher Dobson values indicate greater concentrations of stratospheric ozone protection.

14. (C) It splits into an O_2 molecule and a free O atom.
Upon absorbing energetic solar ultraviolet radiation in the stratospheric layer, a triatomic ozone molecule undergoes photo-dissociation. This radiative interaction breaks chemical bonds within the molecule, yielding one stable diatomic oxygen molecule and a reactive free oxygen atom. This continuous photo-dissociation and reformation cycle absorbs hazardous solar ultraviolet rays before they reach land.

15. (A) P-2, Q-3, R-1, S-4
Freon-11 functions as a synthetic cooling refrigerant, while methane serves as the primary hydrocarbon constituent of compressed natural gas fuel. Butane is a major hydrocarbon compound present in liquefied petroleum gas, and ethyl mercaptan is an odorant additive used for gas leak detection. Each chemical substance maps precisely to its characteristic application.

16. (C) Evaporation of a liquid absorbs heat to cause cooling.
Refrigeration relies fundamentally on phase change principles, specifically latent heat absorption during liquid evaporation. When a volatile liquid refrigerant absorbs heat energy from its surrounding environment inside an evaporator coil, it transforms into vapor. This endothermic absorption process lowers the surrounding temperature, creating a continuous localized cooling effect inside the thermal system.

17. (B) Methane
Methane is a potent greenhouse gas generated heavily through agricultural activities like flooded paddy rice cultivation and enteric fermentation in ruminant livestock digestions. Methanogenic archaea thrive in anaerobic soil environments and animal digestive systems, breaking down organic matter and releasing gas into the atmosphere. Reducing these agricultural emissions is critical for climate change mitigation.

18. (D) It burns completely, producing negligible unburnt hydrocarbons.
Compressed natural gas is categorized as a clean automotive fuel because its simple hydrocarbon structure promotes complete combustion in vehicle engines. Complete burning yields carbon dioxide and water vapor, producing negligible amounts of unburnt hydrocarbons, soot particulate matter, and carbon monoxide compared to complex liquid petroleum fuels like petrol or diesel.

19. (A) Greenhouse effect
The greenhouse effect is a natural planetary phenomenon where atmospheric trace gases absorb outgoing longwave infrared radiation

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emitted by Earth's surface. Instead of escaping into space, this thermal energy is re-radiated in all directions, trapping heat within the atmosphere. Increased anthropogenic emissions enhance this natural mechanism, driving global warming and climate change.

20. (B) I and III only
Burning compressed natural gas releases significantly less carbon monoxide than conventional petrol because methane undergoes more efficient complete combustion. Furthermore, natural gas contains no lead additives, protecting health and environment. However, natural gas produces negligible sulfur dioxide compared to diesel, making the statement claiming higher sulfur dioxide emissions from compressed natural gas false.

21. (A) Water vapor
Water vapor is the primary natural greenhouse gas responsible for the largest portion of Earth's atmospheric heat retention. Operating within a powerful natural feedback loop, water vapor absorbs outgoing terrestrial infrared radiation across multiple wavebands. While human activities directly increase carbon dioxide levels, naturally occurring atmospheric water vapor maintains baseline thermal planetary equilibrium.

22. (D) $CFCl_3$
Freon-11 is the commercial name for trichlorofluoromethane, represented chemically by the formula $CFCl_3$. Its structure consists of a single central carbon atom bonded to one fluorine atom and three chlorine atoms. This halogenated chlorofluorocarbon compound was historically utilized as a refrigerant, foam blowing agent, and propellant before global phase-out mandates.

23. (B) It functions as a propellant to expel can contents.
In aerosol spray cans, Freon was utilized primarily as a gaseous propellant to generate internal pressure. When the spray valve is opened, the compressed volatile liquid vaporizes, forcing liquid product contents out through the nozzle as a fine mist. Its physical volatility and chemical inertness made it ideal for aerosol dispensing.

24. (C) A drastic ozone reduction over Antarctica during polar spring.
The discovery of the ozone hole refers to a severe seasonal thinning of stratospheric ozone concentrations observed over Antarctica during polar spring months. Atmospheric scientists detected dramatic drops in ozone Dobson units caused by polar stratospheric clouds and chlorine chemistry. This scientific finding alerted the global community to anthropogenic chlorofluorocarbon destruction.

25. (B) Carbon dioxide > Methane > CFCs > Nitrous oxide
Carbon dioxide contributes the highest overall proportion to anthropogenic global warming due to immense atmospheric volume emissions. Methane ranks second in cumulative warming influence, followed by synthetic chlorofluorocarbons and nitrous oxide gases. This sequence reflects the total relative contribution of each greenhouse gas to overall global atmospheric radiative heating effects worldwide.

26. (A) C-Cl bond
Stratospheric UV radiation breaks the carbon-chlorine bond in a chlorofluorocarbon molecule because this specific covalent bond has lower bond energy than the carbon-fluorine bond. Photolytic cleavage releases a reactive chlorine free radical, which immediately reacts with stratospheric ozone. This homolytic cleavage reaction initiates the destructive catalytic cycle depleting stratospheric ozone.

27. (D) 80-90%
Commercial compressed natural gas contains approximately eighty to ninety percent methane by total volume, alongside minor fractions of ethane, propane, and nitrogen. This high methane percentage gives the fuel a elevated calorific energy value and permits efficient combustion in modified engines, solidifying its place as a popular low-emission alternative.

28. (B) Used as a raw material for producing fertilizers.
Beyond its application as a thermal fuel source, natural gas serves as a critical chemical feedstock in industrial fertilizer manufacturing. High-temperature steam methane reforming extracts elemental hydrogen from natural gas, which is subsequently combined with atmospheric nitrogen to produce synthetic ammonia. Ammonia forms

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the base compound for nitrogenous agricultural fertilizers.

29. (A) It consists mainly of methane and ethane.
Liquefied petroleum gas consists primarily of propane and butane hydrocarbon molecules, whereas methane and ethane are the primary components of natural gas. Liquefied petroleum gas is stored as a liquid under moderate pressure, possesses high energy density, and is heavier than air. Stating that it consists mainly of methane is incorrect.

30. (A) P-2, Q-1, R-4, S-3
Sulfur dioxide is a principal atmospheric pollutant causing acid rain formation, while chlorofluorocarbons cause stratospheric ozone layer depletion. Carbon dioxide is the primary anthropogenic greenhouse gas driving global climate warming, and ethyl mercaptan is an essential odorant additive mixed into odorless domestic fuel gases to ensure rapid leak detection.

31. (D) A stratospheric region with reduced ozone levels.
The ozone hole does not represent a literal physical void in the atmosphere devoid of air molecules. Instead, it describes a localized stratospheric region where total column ozone concentration falls significantly below normal levels, typically measured under two hundred Dobson units. This thinning reduces the atmosphere's capability to absorb ultraviolet radiation.

32. (C) Public and private road transport
In India, the rapid adoption of compressed natural gas has been driven primarily by the public and private road transport sectors. Government regulations mandated compressed natural gas conversion for public transit buses, auto-rickshaws, commercial taxis, and private cars in urban centers to mitigate severe particulate matter and air pollution levels.

33. (B) 1987
The Montreal Protocol on Substances that Deplete the Ozone Layer was open for signature in September 1987 and entered into force in 1989. This landmark global treaty established strict timelines for phasing out industrial production of ozone-depleting chemicals, establishing an effective international framework for environmental restoration and atmospheric protection.

34. (D) They are potent greenhouse gases.
Although hydrofluorocarbons do not damage the ozone layer because they lack chlorine atoms, they present a major environmental drawback due to their high global warming potential. These synthetic chemicals trap infrared radiation thousands of times more effectively than carbon dioxide, contributing significantly to atmospheric climate change when released into air.

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35. (A) Compressed Natural Gas
Compressed natural gas stands out from refined petrol, diesel, and mineral coal because it is stored and utilized strictly in a compressed gaseous state. In contrast, petrol and diesel are refined liquid petroleum fuels, while coal is a solid mineral fuel. This fundamental difference in physical state distinguishes compressed natural gas.

36. (C) Expansion of the ozone hole
Global warming refers to the persistent increase in Earth's global average surface temperature, driving sea level rise, melting glaciers, and severe weather patterns. Stratospheric ozone depletion is a distinct atmospheric phenomenon caused by halogenated chemical compounds. While both represent global environmental challenges, global warming does not cause expansion of the ozone hole.

37. (A) It easily changes state under pressure.
Freon possessed favorable thermodynamic properties, transitioning easily between liquid and gaseous states under manageable mechanical pressures and temperatures. This facile phase change capability allowed efficient heat absorption during liquid vaporization and heat release during compression condensation, making it ideal for refrigeration cycles within mechanical air conditioning and cooling systems.

38. (D) Ethyl mercaptan
Liquefied petroleum gas is naturally odorless, making accidental leak detection difficult. To protect consumers from fire hazards, manufacturers add small quantities of ethyl mercaptan, a sulfur-containing organic compound with a strong, distinct odor resembling rotten cabbage. This additive ensures immediate human detection of escaping gas even at extremely low concentrations.

39. (B) Petroleum deposits
Natural gas deposits are commonly discovered geographically alongside crude oil reservoirs deep within underground geological formations. Formed from ancient organic marine sediments subjected to high pressure and geological heat over millions of years, natural gas exists either dissolved in crude oil or accumulated above liquid petroleum deposits as a gas cap.

40. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Chlorofluorocarbons remain highly stable in the lower troposphere because they do not react with common chemical species. However, upon ascending to the stratosphere, they encounter high-energy ultraviolet radiation. These energetic photons break strong carbon-chlorine covalent bonds through photolysis, releasing reactive chlorine radicals that destroy ozone, making the explanation scientifically accurate.

41. (D) Gas
Inside vehicle fuel cylinders, compressed natural gas is stored strictly in a high-pressure gaseous state rather than as a liquid. Mechanical compressors compress the purified methane gas to high pressures between two hundred and two hundred fifty bar, maintaining its gaseous state without cooling it down to cryogenic liquid temperatures.

42. (A) As an automotive fuel
Compressed natural gas is utilized primarily today as an alternative automotive fuel for internal combustion engines in cars, buses, and commercial vehicles. Replacing conventional petrol and diesel, compressed natural gas burns cleanly, reducing carbon monoxide, unburnt hydrocarbons, and fine particulate emissions within heavily populated urban transportation networks.

43. (B) Skin cancer and cataracts
Increased terrestrial exposure to stratospheric UV-B radiation resulting from ozone depletion causes cellular and genetic damage in living organisms. In humans, prolonged exposure damages DNA in dermal tissue and ocular lenses, directly leading to elevated incidences of non-melanoma skin cancers, malignant melanomas, cortical cataracts, and various eye disorders.

44. (B) Fossil fuel combustion
The combustion of fossil fuels such as coal, heavy fuel oil, petrol, and diesel represents the primary source of industrial atmospheric pollution. Burning these organic carbon fuels releases substantial quantities of sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide, and fine particulate matter into urban air, causing severe environmental pollution.

45. (A) P-2, Q-4, R-3, S-1
Carbon dioxide is released primarily through fossil fuel combustion in energy and transport sectors. Methane originates heavily from biological activity in paddy fields and enteric fermentation in livestock. Nitrous oxide stems from agricultural soil management and chemical fertilizer usage, while chlorofluorocarbons are synthetic compounds emitted from refrigeration and aerosol devices.

46. (C) Heat trapped by a gas relative to CO_2.
Global Warming Potential measures the relative quantity of thermal heat trapped in the atmosphere by a specific greenhouse gas compared to carbon dioxide over a designated timeframe. Standardized with carbon dioxide assigned a baseline value of one, this metric allows environmental scientists to compare the radiative forcing impacts of different gases.

47. (D) From Petrol to Electric vehicles
Transitioning from petrol vehicles to electric vehicles represents a key structural shift toward sustainable transport energy systems. Electric vehicles produce zero tailpipe emissions and can be powered by renewable electricity sources like solar or wind power. This technological migration reduces urban air pollution, greenhouse gas emissions, and fossil fuel dependency.

48. (C) It is primarily concentrated in the stratosphere.
The atmospheric ozone layer is concentrated within the stratospheric layer, situated roughly fifteen to thirty-five kilometers above Earth. Here, naturally occurring triatomic ozone molecules absorb hazardous solar ultraviolet-B radiation, preventing it from reaching the surface. It is formed via photochemical reactions involving diatomic oxygen and solar UV light, not carbon dioxide.

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49. (B) Biodiesel
Biodiesel is a renewable alternative fuel produced through the transesterification of vegetable oils, animal fats, or recycled restaurant grease. Unlike conventional petroleum-derived fuels like petrol, diesel, and kerosene, biodiesel reduces net life-cycle greenhouse gas emissions and decreases national dependency on finite fossil fuel reserves for transportation and machinery.

50. (C) I and III only
Inhaling high concentrations of Freon in confined spaces causes central nervous system depression, dizziness, headaches, and eventual asphyxiation because dense gas displaces breathable ambient oxygen. However, Freon does not cause direct permanent genetic mutations in lung tissues. Therefore, statements regarding acute dizziness and oxygen displacement are correct, while mutation claims are false.

51. (C) 50 - 55 kJ/g
The calorific value of compressed natural gas ranges approximately between fifty and fifty-five kilojoules per gram, equivalent to fifty thousand to fifty-five thousand kilojoules per kilogram. This high energy content per unit mass reflects its high methane concentration, making it an efficient combustion fuel for vehicle engines and power generation.

52. (C) Chlorine, Fluorine, Carbon
Chlorofluorocarbons are synthetic chemical compounds composed exclusively of chlorine, fluorine, and carbon atoms. These volatile organic derivatives contain no hydrogen atoms in their basic molecular structure, imparting remarkable chemical inertia and thermal stability. Their unique chemical composition allowed widespread industrial application as refrigerants, solvents, and blowing agents before environmental regulations.

53. (A) High pressure compression without liquefaction.
Processing natural gas into compressed natural gas involves mechanical compression to high pressures between two hundred and two hundred fifty bar without converting the gas into a liquid state. Kept above its critical temperature during standard storage, methane remains fully gaseous, delivering compact energy storage for vehicular transport applications.

54. (D) It destroys phytoplankton, disrupting food webs.
Stratospheric ozone depletion allows excessive ultraviolet-B radiation to penetrate surface ocean waters, damaging microscopic marine phytoplankton. Phytoplankton form the foundational base of aquatic food webs and drive ocean carbon fixation. Solar ultraviolet damage impairs their photosynthesis and survival, causing ecological disruptions across marine ecosystems and marine fish populations.

55. (B) II, III, I, IV
High-energy ultraviolet radiation breaks the carbon-chlorine bond in a chlorofluorocarbon molecule, releasing a free chlorine atom into the stratosphere. The chlorine atom reacts with ozone to form chlorine monoxide and diatomic oxygen. Subsequently, chlorine monoxide reacts with a free oxygen atom, regenerating the chlorine radical to destroy more ozone molecules.

56. (C) Nitrogen
Molecular nitrogen makes up roughly seventy-eight percent of Earth's atmosphere but is not a greenhouse gas because its homonuclear diatomic structure lacks a dipole moment. Consequently, it cannot absorb or emit infrared radiation. In contrast, molecules like carbon dioxide, methane, and water vapor absorb terrestrial thermal radiation, acting as greenhouse gases.

57. (D) Unburnt hydrocarbons and particulates
Vehicles running on compressed natural gas emit drastically reduced levels of unburnt hydrocarbons and particulate matter compared to petrol or diesel engines. Methane's simple gaseous molecular structure undergoes thorough mixing with intake air, achieving complete combustion inside engine cylinders and avoiding the carbon soot formations typical of heavier liquid hydrocarbon fuels.

58. (A) It emits minimal sulfur oxides and lower nitrogen oxides.
Natural gas combustion aids air pollution control because purified natural gas contains negligible sulfur impurities, eliminating sulfur dioxide tailpipe emissions. Additionally, lower peak combustion temperatures and cleaner burning characteristics produce fewer nitrogen oxides and particulate emissions than burning diesel or coal, helping reduce urban smog and acid rain formation.

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59. (B) Cylinders must withstand very high pressure.
Storing compressed natural gas safely requires seamless, high-strength fuel cylinders engineered to endure high operational pressures ranging between two hundred and two hundred fifty bar. These specialized storage vessels undergo rigorous pressure testing and structural checks to prevent accidental mechanical failure, gas leakage, or structural rupture during vehicle operation and refueling.

60. (A) P-3, Q-4, R-2, S-1
Compressed natural gas is gaseous fuel compressed at high pressure for motor vehicles, whereas liquefied petroleum gas is liquefied under moderate pressure for domestic cooking. Petrol is a liquid petroleum distillate used in light motor vehicles, and coal is a solid carbonaceous fossil fuel associated with high greenhouse gas emissions.

61. (A) A fuel producing minimal emissions on burning.
A clean fuel refers to an energy source that produces minimal atmospheric pollutants and toxic emissions upon combustion compared to traditional fuels. Clean fuels emit significantly fewer particulates, carbon monoxide, sulfur compounds, and unburnt hydrocarbons, mitigating environmental degradation, smog formation, and public health risks associated with degraded ambient air quality.

62. (C) UV radiation action on oxygen molecules
Stratospheric ozone is created naturally through photochemical reactions initiated by solar ultraviolet radiation. High-energy solar ultraviolet photons split diatomic oxygen molecules into individual oxygen atoms. Each free oxygen atom then combines with an intact diatomic oxygen molecule to form triatomic ozone, maintaining a natural dynamic equilibrium within the stratospheric ozone layer.

63. (D) Because it is emitted in vastly larger quantities.
Although individual chlorofluorocarbon molecules possess higher global warming potentials than carbon dioxide, carbon dioxide remains the primary driver of anthropogenic climate change because human industrial activities emit it in immense volume quantities. Mass fossil fuel combustion and global deforestation continuously release gigatons of carbon dioxide into the global atmosphere.

64. (C) LPG - Liquefied butane and propane
Liquefied petroleum gas consists mainly of liquefied butane and propane hydrocarbons stored under moderate pressure. Freon is a synthetic refrigerant rather than a cooking fuel, and compressed natural gas is highly compressed methane gas. Stratospheric ozone plays a crucial protective role shielding Earth from harmful solar ultraviolet radiation.

65. (B) Chloro Fluoro Carbon
The acronym CFC stands for chlorofluorocarbon, representing a group of synthetic organic compounds containing chlorine, fluorine, and carbon atoms. Known commercially under trade names like Freon, these non-flammable volatile chemicals were widely produced during the twentieth century for refrigeration, industrial solvents, and aerosol applications before being phased out globally.

66. (C) 200 to 250 bar
Vehicle fuel cylinders for compressed natural gas operate at working pressures between two hundred and two hundred fifty bar. Compressing methane gas to this high pressure reduces its volume by over two hundred times, providing sufficient fuel storage density to give natural gas vehicles acceptable driving ranges without occupying excessive space.

67. (A) Its volatility and pressure exertion capability.
Freon was selected as an aerosol propellant because of its high chemical volatility and capability to exert consistent vapor pressure within sealed containers. At ambient temperatures, liquefied Freon vaporizes inside the spray can, maintaining steady internal pressure to force liquid products out through the valve nozzle as a fine, uniform aerosol mist.

68. (C) Infrared thermal heat
Earth's atmosphere traps thermal energy in a manner analogous to physical glass green houses. Incoming shortwave solar radiation passes through atmospheric gases and warms Earth's terrestrial surface. The surface re-emits this thermal energy as longwave infrared radiation, which is absorbed and re-radiated by greenhouse gases, keeping the planet thermally habitable.

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69. (A) Wetlands and marshes
Natural wetlands and marshes represent the single largest natural biological source of atmospheric methane emissions globally. In these waterlogged, oxygen-depleted soil environments, anaerobic methanogenic microorganisms break down decaying organic vegetation. This anaerobic decomposition process generates methane gas, which bubbles up through water columns and escapes into the surrounding atmosphere.

70. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Transitioning urban public transit buses from diesel to compressed natural gas successfully reduced air pollution in major metropolitan cities. Compressed natural gas combustion releases minimal soot, particulate matter, and carbon monoxide compared to diesel fuel combustion. Thus, cleaner combustion characteristics directly explain why adopting compressed natural gas improved urban air quality.

71. (D) 100,000
A single chlorine radical released from a chlorofluorocarbon molecule inside the stratosphere can break down approximately one hundred thousand ozone molecules through a catalytic cycle. Because the chlorine radical is regenerated at the end of each reaction cycle, it continuously destroys stratospheric ozone until bound by trace reservoir species like nitrogen dioxide.

72. (C) Installing electrostatic precipitators
An electrostatic precipitator is a filtration device used in industrial facilities to remove particulate matter from industrial flue gases. By applying high-voltage electrical charges to suspended particles in gas streams, the device attracts charged soot and fly ash onto collection plates, preventing fine particulate air pollution from entering ambient air.

73. (D) Long-term shifts in temperatures and weather patterns.
Climate change describes long-term, multi-decadal shifts in global surface temperatures, atmospheric precipitation, and weather patterns. Unlike day-to-day weather variations, modern climate change is driven primarily by human activities, especially fossil fuel combustion and deforestation, which elevate greenhouse gas concentrations and alter Earth's global thermal radiation budget.

74. (A) Natural gas deposits
Compressed natural gas is sourced directly from geological natural gas deposits located deep underground in porous rock formations. Extracted through drilling, raw natural gas undergoes processing to remove water vapor, hydrogen sulfide, and heavy hydrocarbons before being compressed into high-pressure fuel suitable for industrial distribution and vehicular transportation systems.

75. (A) P-2, Q-3, R-4, S-1
Chlorofluorocarbons are primary agents causing stratospheric ozone layer depletion, while carbon dioxide is the dominant gas driving the enhanced greenhouse effect. Incomplete combustion in unvented indoor stoves releases toxic carbon monoxide, and urban photochemical smog formation is driven by photochemical reactions involving nitrogen oxides and volatile organic compounds.

76. (B) It expands rapidly, dropping in pressure and temperature.
When liquid refrigerant passes through an expansion valve inside an air conditioning system, it encounters a sudden restriction drop in flow pressure. This rapid pressure drop causes quick expansion and partial vaporization, causing the refrigerant's temperature to plummet rapidly. Cold low-pressure fluid then absorbs thermal heat within evaporator coils.

77. (A) It is thickest near the equator and thinnest at the poles.
Atmospheric stratospheric ozone is naturally thinnest over tropical equatorial regions and thickest over subpolar polar regions due to global stratospheric wind circulation patterns known as the Brewer-Dobson circulation. Stating that the ozone layer is naturally thickest at the equator and thinnest at the poles is scientifically incorrect.

78. (C) Bio-CNG
Bio-CNG is a renewable alternative fuel produced by purifying biomethane derived from anaerobic digestion of organic waste and agricultural residues. Purified to over ninety percent methane content, Bio-CNG possesses identical combustion characteristics to fossil compressed

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natural gas while providing a sustainable, circular carbon-neutral energy source for transportation networks.

79. (A) 100,000 Pascals (100 kPa)
One bar is a metric pressure unit defined as exactly one hundred thousand Pascals, equivalent to one hundred kilopascals. Derived from atmospheric pressure measurements, it provides a convenient unit for expressing elevated pressures in mechanical systems, gas storage cylinders, compressed natural gas tanks, and industrial chemical process applications worldwide.

80. (A) I and II only
Replacing high-sulfur coal with natural gas reduces sulfur dioxide emissions, and flue-gas scrubbers strip acidic gases from smokestack flues. However, increasing chimney heights merely disperses pollutants over wider areas without reducing total greenhouse gas output. Therefore, statements regarding fuel switching and scrubbers are correct, while chimney height claims are false.

81. (B) Fossil fuels to renewable energy sources.
The transition toward sustainable energy involves shifting away from finite carbon-intensive fossil fuels like coal, oil, and natural gas toward clean, renewable energy sources such as solar, wind, hydro, and geothermal energy. This global transition aims to reduce greenhouse gas emissions, limit climate warming, and protect ecological biodiversity.

82. (D) Essential medical inhalers lacking suitable substitutes.
Under the Montreal Protocol, temporary critical-use exemptions were granted for essential medical applications, notably metered-dose inhalers used by asthma patients, where technically viable non-CFC substitutes were initially unavailable. Commercial automotive air conditioning, household refrigeration, and cosmetic propellant applications were phased out without receiving critical essential-use exemptions.

83. (A) It eliminates road transport and lowers emissions.
Transporting natural gas through pipeline distribution networks is highly efficient because it eliminates heavy tanker trucks from road networks, lowering fuel consumption, vehicular traffic congestion, and transportation emissions. Continuous pipeline flow delivers natural gas directly to urban distribution stations and consumers reliably with minimal handling loss or safety risks.

84. (C) It emits half as much CO_2 per unit energy.
Natural gas provides a significant environmental advantage over coal in power generation because burning natural gas releases roughly fifty percent less carbon dioxide per unit of electrical energy generated. Higher hydrogen-to-carbon ratios in methane yield superior thermodynamic efficiency and cleaner combustion compared to solid carbon-rich mineral coal.

85. (B) Troposphere, Stratosphere, Mesosphere, Thermosphere
Starting from Earth's surface and moving upward toward space, the atmospheric layers are structured sequentially as the troposphere, stratosphere, mesosphere, and thermosphere. The troposphere contains weather phenomena, the stratosphere houses protective ozone, the mesosphere burns incoming meteors, and the thermosphere absorbs high-energy solar radiation.

86. (D) Unreactivity in lower air lets them reach the stratosphere.
Chlorofluorocarbons do not react with atmospheric hydroxyl radicals or dissolve in precipitation within the lower troposphere due to their high chemical stability. This lack of tropospheric loss pathways allows chlorofluorocarbon molecules to persist intact for decades, slowly ascending into the stratosphere where energetic UV radiation triggers destructive ozone chemistry.

87. (B) To meet emission norms and cut fuel costs.
Retrofitting petrol and diesel vehicles with compressed natural gas conversion kits allows vehicle owners to comply with urban emission standards while lowering fuel expenditure. Compressed natural gas burns cleaner than liquid fuels and is less expensive per kilometer, offering economic savings and lower environmental emissions for urban drivers.

88. (C) CNG is stored at much higher pressure than LPG.
Compressed natural gas is stored as a high-pressure gas at pressures between two hundred and two hundred fifty bar, whereas liquefied

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petroleum gas is stored as a liquid under moderate pressure around seven to ten bar. Compressed natural gas consists mainly of methane and is lighter than air, unlike heavier propane-butane mixtures.

89. (D) Ingredient in concrete cement mixing.
Natural gas serves as an industrial fuel in boilers, a feedstock for ammonia fertilizer manufacturing, and a source for hydrogen gas production. However, natural gas is a hydrocarbon fuel and chemical feedstock that plays no structural or chemical role as an additive or ingredient in mixing concrete cement mortar.

90. (A) P-3, Q-1, R-2, S-4
Ozone Depletion Potential measures a chemical compound's relative capability to destroy stratospheric ozone, whereas Global Warming Potential quantifies heat-trapping capacity relative to carbon dioxide. Compressed natural gas is compressed gaseous methane used in motor vehicles, and liquefied petroleum gas is a liquefied hydrocarbon mixture used in domestic cooking.

91. (B) Chlorofluorocarbons
The global thinning of Earth's stratospheric ozone layer during the late twentieth century was caused primarily by mass emissions of chlorofluorocarbons. These synthetic volatile compounds released free chlorine radicals under UV radiation, destroying ozone molecules faster than natural atmospheric processes could reform them until international treaties banned their production worldwide.

92. (B) Ethyl mercaptan
The distinct pungent smell noticed during a liquefied petroleum gas leak is caused by ethyl mercaptan, an odorant additive mixed into odorless commercial butane and propane. Because natural petroleum gases are odorless, adding small amounts of this volatile sulfur compound ensures rapid leak detection, preventing flammable gas accumulations and explosions.

93. (A) It traps Earth's infrared heat far more efficiently than CO_2.
Methane is a powerful greenhouse gas because its molecular structure absorbs Earth's outgoing infrared radiation far more effectively than carbon dioxide on a per-molecule basis. Over a twenty-year atmospheric timeframe, methane exhibits a global warming potential over eighty times greater than carbon dioxide, driving rapid near-term climate warming.

94. (C) High chemical reactivity with cooling metals.
Freon compounds were widely used as refrigerants because they exhibit high chemical stability and non-corrosive properties toward refrigeration hardware metals like copper, aluminum, and steel. Stating that Freon exhibits high chemical reactivity with cooling system metals is incorrect, as its non-corrosive nature was a primary engineering advantage for appliances.

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95. (B) III, IV, II, I
The compressed natural gas supply chain begins with extracting raw gas from natural gas wells. Extracted natural gas undergoes purification to remove water vapor and sulfur compounds. Next, clean gas is mechanically compressed to two hundred to two hundred fifty bar and finally dispensed into vehicle storage cylinders at stations.

96. (C) CNG is mostly methane, whereas LPG is propane and butane.
The key difference in chemical composition between compressed natural gas and liquefied petroleum gas lies in their constituent hydrocarbons. Compressed natural gas consists primarily of methane, a single-carbon alkane. In contrast, liquefied petroleum gas consists of three-carbon propane and four-carbon butane hydrocarbons, which liquefy easily under moderate pressure.

97. (B) Chlorine
Hydrofluorocarbons are ozone-friendly because their chemical structure lacks chlorine atoms entirely, containing only carbon, hydrogen, and fluorine. Without chlorine, these synthetic compounds cannot generate catalytic chlorine radicals when exposed to stratospheric solar ultraviolet light, resulting in zero ozone depletion potential and safeguarding the atmospheric ozone layer.

98. (D) Worsening of respiratory diseases like asthma.
Elevated concentrations of urban air pollutants and associated emissions exacerbate chronic respiratory conditions such as bronchial asthma, chronic obstructive pulmonary disease, and

bronchitis. Fine particulate matter, nitrogen oxides, and ground-level ozone irritate pulmonary airways, triggering airway inflammation, severe coughing, reduced pulmonary function, and emergency hospitalizations.

99. (A) HFCs
The Kigali Amendment to the Montreal Protocol, adopted in 2016, aims to phase down global production and consumption of hydrofluorocarbons. Although hydrofluorocarbons do not deplete stratospheric ozone, they possess high global warming potentials. Phasing them down prevents up to zero point five degrees Celsius of global temperature rise by 2100.

100. (C) Assertion (A) is true but Reason (R) is false.
Carbon dioxide is the most significant anthropogenic greenhouse gas due to its immense atmospheric emissions from fossil fuel burning. However, carbon dioxide does not have the highest global warming potential per molecule; synthetic gases like CFCs and sulfur hexafluoride have GWPs thousands of times higher, making the reason statement false.

101. (A) Afforestation and planting trees
Afforestation and tree planting do not contribute to atmospheric pollution; instead, they improve air quality and sequester carbon. Growing trees absorb carbon dioxide through biological photosynthesis, remove fine airborne particulate matter on leaf surfaces, and release fresh oxygen gas into the surrounding air, countering industrial emissions and urban air degradation.

102. (D) Exothermic combustion
When compressed natural gas is used as fuel inside an internal combustion engine, methane reacts rapidly with oxygen gas in an exothermic combustion reaction. This chemical oxidation breaks hydrocarbon bonds, yielding carbon dioxide and water vapor while releasing substantial heat energy. Thermal expansion of heated gases drives mechanical pistons.

103. (B) It has been phased out due to ozone depletion.
Freon refrigerants have been phased out globally under the Montreal Protocol because their atmospheric release causes severe stratospheric ozone depletion. Modern household refrigerators and cooling appliances utilize non-ozone-depleting alternatives such as hydrofluorocarbons, hydrofluoroolefins, and natural hydrocarbon refrigerants like isobutane to meet international environmental regulations.

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104. (C) Compressed Natural Gas
Compressed natural gas is stored strictly in a gaseous state under high pressure within vehicle fuel cylinders. In contrast, refined petrol, diesel fuel, and liquefied petroleum gas are stored in liquid form under standard vehicle storage conditions. Compressed natural gas is the only fuel among those listed maintained as a compressed gas.

105. (A) P-2, Q-4, R-3, S-1
CH_4 represents methane, the simplest alkane and primary constituent of natural gas. O_3 represents ozone, a triatomic oxygen molecule. CF_2Cl_2 represents dichlorodifluoromethane, commercially known as Freon-12. C_4H_{10} represents butane, a four-carbon alkane commonly found in liquefied petroleum gas cooking cylinders.

106. (A) Antarctica
Severe stratospheric ozone depletion was observed most dramatically over Antarctica during polar spring. Unique atmospheric conditions, including extremely cold temperatures, polar stratospheric clouds, and the isolated polar vortex, concentrated reactive chlorine species. These factors accelerated catalytic ozone destruction, creating the famous Antarctic ozone hole annually.

107. (B) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
The complete combustion of methane, the primary component of compressed natural gas, is represented by the balanced equation $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. One molecule of methane reacts with two molecules of oxygen gas to produce one molecule of carbon dioxide and two molecules of water vapor, releasing energy.

108. (B) Because they are potent greenhouse gases.
Finding alternatives to hydrofluorocarbons is necessary because they are potent greenhouse gases with high global warming potentials, despite being safe for stratospheric ozone. Their atmospheric accumulation traps thermal heat thousands of times more effectively than carbon dioxide, prompting international agreements like the Kigali Amendment to phase them out worldwide.

109. (A) Fertilizer production
The fertilizer manufacturing industry represents the largest industrial consumer of natural gas, utilizing methane as a critical chemical feedstock. Through steam methane reforming, natural gas yields hydrogen gas, which is combined with atmospheric nitrogen in the Haber-Bosch process to synthesize ammonia, the foundation for worldwide nitrogenous fertilizer production.

110. (A) I and II only
Bio-CNG and renewable fuels reduce dependency on imported crude oil and lower overall carbon footprints relative to conventional fossil fuels. However, no combustion fuel produces zero emissions under all operating conditions, as burning organic fuels still yields carbon dioxide and water vapor. Thus, statements one and two are correct.

111. (D) To convert toxic exhaust gases into CO_2 and water.
A catalytic converter is an exhaust emission control device installed in motor vehicles to convert toxic combustion gases into harmless substances. Utilizing noble metal catalysts like platinum, palladium, and rhodium, it oxidizes unburnt hydrocarbons and carbon monoxide into carbon dioxide and water vapor while reducing nitrogen oxides into nitrogen gas.

112. (C) Total greenhouse gases caused by human actions.
A carbon footprint measures the total cumulative quantity of greenhouse gas emissions generated directly or indirectly by human activities, organizations, products, or events. Expressed in units of carbon dioxide equivalent, this environmental metric quantifies individual and collective climate impacts, aiding targeted strategies to mitigate global warming and resource consumption.

113. (B) It is lighter than air and dissipates quickly.
Compressed natural gas consists primarily of methane, which has a lower density than atmospheric air. In the event of an accidental leak in an open space, escaping natural gas rises rapidly into the upper atmosphere and dissipates quickly, preventing explosive localized gas accumulations near ground level and enhancing safety.

114. (D) It phased out ozone-depleting substances, aiding recovery.
The Montreal Protocol is regarded as a successful international treaty because it established binding global schedules to phase out the production and consumption of ozone-depleting substances like chlorofluorocarbons. Global compliance halted stratospheric ozone layer degradation, allowing atmospheric ozone concentrations to begin recovering toward historical pre-1980 levels.

115. (A) P-3, Q-4, R-1, S-2
First-generation historical refrigerants like ammonia and sulfur dioxide were toxic and flammable. Second-generation chlorofluorocarbons possessed high ozone depletion and global warming potentials. Third-generation hydrofluorocarbons feature low ozone depletion but high global warming potential, whereas fourth-generation natural refrigerants possess zero ozone depletion and minimal global warming potential.

116. (C) Used as a coolant in refrigerators and car ACs.
Before global environmental bans took effect, Freon was widely utilized as a chemical coolant in household refrigerators, commercial freezers, and automotive air conditioning systems. Its chemical stability, low toxicity, non-flammability, and favorable thermodynamic phase-change properties made it the dominant refrigeration gas across global consumer appliance industries.

117. (A) It builds infrastructure and cuts oil import bills.
Expanding compressed natural gas usage in public transit benefits national economies by reducing dependency on imported crude oil, lowering foreign currency expenditure. Furthermore, establishing natural gas refueling stations, pipeline networks, and vehicle retrofitting industries stimulates domestic infrastructure investment, job creation, and long-term economic sustainability in urban centers.

118. (D) Using cleaner fuels like natural gas instead of coal.
Switching from dirty fossil fuels like coal to cleaner energy sources like natural gas represents an effective source-control measure for industrial emissions. Natural gas contains negligible sulfur and burns completely, significantly reducing atmospheric output of sulfur dioxide, particulate

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matter, soot, and toxic heavy metals from industrial smokestacks.

119. (B) It requires large, heavy, pressurized storage tanks.
A main disadvantage of natural gas compared to liquid petrol or diesel is its low volumetric energy density at ambient pressure. To store adequate energy for practical driving ranges, vehicles require large, heavy, thick-walled steel or composite storage cylinders capable of safely withstanding high pressures up to two hundred fifty bar.

120. (A) I and II only
Compressed natural gas is stored as a high-pressure gas containing mainly methane, whereas liquefied petroleum gas is stored as a liquid under moderate pressure containing propane and butane. However, liquefied petroleum gas has a higher calorific value per kilogram than compressed natural gas. Thus, statements one and two are correct.

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CHAPTER 05
Polymers, Soaps and Detergents

1. What is the basic unit from which a polymer is formed?
(A) Isomer
(B) Monomer
(C) Micelle
(D) Isotope

2. Which of the following best defines the process of polymerisation?
(A) The breakdown of a large molecule into smaller fragments
(B) The separation of miscible liquids based on boiling points
(C) The conversion of a solid directly into a gas
(D) The chemical combination of many small molecules to form a large macro-molecule

3. Which of the following is a naturally occurring polymer?
(A) Cellulose
(B) Polythene
(C) Nylon
(D) Polyvinyl chloride

4. Silk is a natural polymer belonging to which of the following chemical classes?
(A) Carbohydrates
(B) Lipids
(C) Proteins
(D) Hydrocarbons

5. The monomer of natural rubber is known as:
(A) Isoprene
(B) Ethene
(C) Vinyl chloride
(D) Caprolactam

6. Which of the following pairs of natural polymer and its source is incorrect?
(A) Cellulose - Plant cell walls
(B) Silk - Silkworm cocoons
(C) Natural rubber - Latex of Hevea brasiliensis
(D) Glycogen - Cotton fibers

7. Match the polymers in List I with their corresponding monomers in List II.
List I: (Polymers)
P. Polythene
Q. Polyvinyl Chloride (PVC)
R. Teflon
S. Natural Rubber
List II: (Monomers)
1. Isoprene
2. Tetrafluoroethene
3. Vinyl chloride
4. Ethene
(A) P-4, Q-2, R-3, S-1
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-3, R-2, S-4

8. Consider the following statements regarding polymerisation:
Statement I: Addition polymerisation involves the repeated addition of monomer molecules possessing double or triple bonds.
Statement II: Condensation polymerisation occurs with the elimination of small molecules like water or alcohol.
Which of the above statement(s) is/are correct?
(A) Only Statement I
(B) Only Statement II
(C) Both Statement I and Statement II
(D) Neither Statement I nor Statement II

9. Which of the following is NOT a characteristic of synthetic polymers?
(A) They are man-made and synthesized in laboratories or factories.
(B) They generally have a higher resistance to environmental degradation compared to natural polymers.
(C) Polythene and nylon are common examples.
(D) They are exclusively composed of amino acid monomers.

10. Identify the odd one out from the given list of polymers based on their origin.
(A) Nylon
(B) Cotton
(C) Jute
(D) Wool

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11. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cellulose is considered a natural polymer.
Reason (R): Cellulose is formed by the condensation of numerous glucose monomers in plants.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

12. Synthetic polymers like polythene are widely used in daily life primarily because they are:
(A) Chemically reactive with water under ambient conditions
(B) Lightweight, durable, and chemically unreactive
(C) Highly expensive and regarded as luxury status symbols
(D) Rapidly biodegradable under normal outdoor soil conditions

13. What is the full form of the synthetic polymer PVC?
(A) Polyvinyl Chloride
(B) Polyvinyl Carbonate
(C) Polyvinyl Cyanide
(D) Polyvinyl Chlorate

14. Which synthetic polymer is commonly used in the manufacture of water pipes and electrical insulation?
(A) Bakelite resin material
(B) Melamine formaldehyde resin
(C) Polyvinyl chloride polymer
(D) Vulcanized natural rubber compound

15. Nylon-6,6 is classified as which type of synthetic polymer?
(A) Polyolefin
(B) Polyester
(C) Polycarbonate
(D) Polyamide

16. The widely used synthetic polyester 'PET', commonly used for making water bottles, stands for:
(A) Polyethylene tetraphthalate
(B) Polyethane triphenyl
(C) Polyethylene terephthalate
(D) Polyester terephthalate

17. Which of the following is a characteristic feature of polyester fibers?
(A) They absorb liquid water and moisture rapidly.
(B) They resist wrinkling and are easy to wash.
(C) They wrinkle very easily and require frequent hot ironing.
(D) They are derived exclusively from natural plant sources.

18. Identify the incorrect statement regarding polythene.
(A) It is formed by the addition polymerisation of ethene.
(B) Low-density polythene (LDPE) is highly branched.
(C) High-density polythene (HDPE) is formed using a Ziegler-Natta catalyst.
(D) It is a classic example of a thermosetting polymer.

19. What is the primary chemical difference between low-density polythene (LDPE) and high-density polythene (HDPE)?
(A) LDPE has branched chains, while HDPE has linear chains.
(B) LDPE is synthesized from ethene, whereas HDPE is synthesized exclusively from propene.
(C) LDPE forms through condensation polymerisation, whereas HDPE forms via addition.
(D) LDPE contains extensive sulfur cross-links, whereas HDPE contains no cross-links.

20. Consider the following statements about synthetic fibers:
I. Nylon was the first fully synthetic fiber made without using any natural raw materials.
II. Nylon fibers are weak and have low elasticity.
III. Polyester fabrics do not get wrinkled easily.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II, and III

21. Which is the most appropriate reason for blending polyester with cotton (to make polycot)?
(A) To combine cotton's breathability with polyester's durability
(B) To transform the woven fabric into an entirely

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waterproof material for heavy rainfall
(C) To significantly elevate the production cost of the textile specifically for export
(D) To make the finished textile dissolve completely and easily during standard washing

22. Identify the correct pair of polymer and its typical everyday use.
(A) Bakelite - Making flexible grocery bags
(B) Polythene - Manufacturing electrical switches
(C) Melamine - Manufacturing rubber tires
(D) Teflon - Non-stick coating on cookware

23. Which of the following statements about the manufacture of polythene is correct?
(A) It is manufactured by reacting ethene gas directly with concentrated sodium hydroxide solution.
(B) It involves heating ethene under pressure with an initiator.
(C) It involves the thermally induced chemical decomposition of polyvinyl chloride resins.
(D) It requires rapidly freezing high-purity ethene gas down to absolute zero temperature.

24. A student wants to select a synthetic fiber that closely resembles wool in its properties but is cheaper. Which polymer should be chosen?
(A) Nylon
(B) Rayon
(C) Acrylic
(D) Polyester

25. What is the fundamental difference between thermoplastics and thermosetting plastics?
(A) Thermoplastics are strictly derived from natural sources, whereas thermosetting plastics are entirely synthetic.
(B) Thermosetting plastics can be repeatedly melted and reshaped, whereas thermoplastics decompose immediately on heating.
(C) Thermoplastics act as electrical insulators, whereas thermosetting plastics serve as excellent conductors of electricity.
(D) Thermoplastics can be remelted, while thermosetting plastics set permanently.

26. Which of the following is a classic example of a thermosetting polymer?
(A) Bakelite
(B) Polyvinyl Chloride (PVC)
(C) Low-density polythene (LDPE)
(D) Polystyrene

27. Why do thermosetting plastics fail to soften on heating after their initial molding?
(A) They possess only weak intermolecular van der Waals forces acting between adjacent chains.
(B) They form 3D cross-links between polymer chains when molded.
(C) They rapidly evaporate and convert directly into gaseous vapors upon heating.
(D) They contain a very high percentage of trapped water molecules that continuously cool them down.

28. Which of the following plastics is used to make electrical switches due to its poor electrical conductivity and thermosetting nature?
(A) Polythene
(B) Bakelite
(C) PVC
(D) PET

29. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): PVC is classified as a thermoplastic polymer.
Reason (R): PVC can be softened on heating and hardened on cooling reversibly.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

30. Which of the following is an example of synthetic rubber?
(A) Cellulose
(B) Isoprene
(C) Neoprene
(D) Glycogen

31. The process of vulcanisation of rubber primarily involves heating natural rubber with which element?
(A) Phosphorus
(B) Nitrogen
(C) Carbon
(D) Sulfur

32. What is the primary purpose of vulcanising natural rubber?
(A) To make the polymer completely soluble in

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cold and warm liquid water
(B) To transform the solid material into a highly fluid thermoplastic liquid state
(C) To increase its tensile strength and elasticity.
(D) To alter its physical appearance by changing its natural color from white to deep black

33. Match the polymer types in List I with their examples in List II.
List I: (Polymer Types)
P. Thermoplastic
Q. Thermosetting plastic
R. Natural Elastomer
S. Synthetic Elastomer
List II: (Examples)
1. Buna-S
2. Natural Rubber
3. Melamine
4. Polystyrene
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

34. Which of the following statements about natural and synthetic rubber is correct?
(A) Natural rubber exhibits much higher tensile strength and structural durability than vulcanised synthetic rubber compounds.
(B) Synthetic elastomer variants like Buna-N and Buna-S are universally recognized as naturally occurring rubber forms.
(C) Natural unvulcanised rubber inherently contains dense sulfur cross-linkages prior to undergoing thermal processing.
(D) Natural rubber comes from tree latex, while synthetic rubber comes from petrochemicals.

35. Buna-S is a widely used synthetic rubber. Its monomers are:
(A) 1,3-Butadiene and Styrene
(B) 1,3-Butadiene and Acrylonitrile
(C) Chloroprene and Isoprene
(D) Vinyl chloride and Ethene

36. During the vulcanisation of rubber, the added sulfur forms:
(A) Strong ionic chemical bonds directly with linear carbon backbone atoms
(B) Intermolecular hydrogen bonds extending between adjacent polymer chains
(C) Cross-links at double bond sites.
(D) An insoluble protective surface layer surrounding the rubber matrix

37. Which of the following everyday items is most likely made from melamine?
(A) Unbreakable crockery
(B) Heavy-duty flexible water hoses
(C) Highly transparent food packaging film
(D) Highly stretchable elastic rubber bands

38. What is the primary environmental concern associated with the widespread use of synthetic plastics?
(A) They continuously consume massive quantities of atmospheric oxygen during storage.
(B) They undergo rapid biological degradation in soil, attracting destructive pest populations.
(C) They readily dissolve in natural rainwater, significantly increasing its acidity level.
(D) They persist in nature, causing environmental pollution.

39. Which of the following is an example of a biodegradable synthetic polymer?
(A) Polyvinyl Chloride polymer (PVC)
(B) PHBV
(C) Polytetrafluoroethylene polymer (Teflon)
(D) High-density polythene polymer (HDPE)

40. Select the correct logical sequence for the standard plastic recycling process.
(A) Melting → Collection → Sorting → Cleaning → Pelletizing
(B) Collection → Sorting → Cleaning → Melting → Pelletizing
(C) Cleaning → Melting → Pelletizing → Collection → Sorting
(D) Sorting → Pelletizing → Collection → Cleaning → Melting

41. In the context of managing polymer waste, what does the 3R principle stand for?
(A) Recycle, Rebuild, Recover
(B) Retain, Remake, Restore
(C) React, Reheat, Recycle
(D) Reduce, Reuse, Recycle

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42. A polymer is termed "non-biodegradable" if it:
(A) Cannot be decomposed by natural biological processes in the environment.
(B) Can be broken down by the action of bacteria and fungi over a short period.
(C) Dissolves completely in water without leaving a trace.
(D) Emits visible light when decomposing.

43. Which of the following represents the best approach for managing non-biodegradable plastic waste?
(A) Incinerating the waste materials in open air to significantly diminish physical volume
(B) Source segregation, recycling, and safe disposal
(C) Directly burying plastic debris into rich agricultural soil to naturally enhance plant nutrients
(D) Discharging unprocessed plastic waste into nearby freshwater rivers and ocean waters

44. What happens when synthetic polymers like PVC are burned in the open environment?
(A) They undergo combustion to release pure breathable oxygen gas into the atmosphere.
(B) They produce toxic hydrogen chloride fumes.
(C) They decompose rapidly to convert directly into nutrient-rich biodegradable compost.
(D) They undergo complete combustion without producing any toxic or harmful air pollutants.

45. Consider the following environmental impacts of plastic pollution:
I. Ingestion of plastics by marine life causes choking and death.
II. Microplastics contaminate soil and disrupt agricultural ecosystems.
III. Plastic waste clogs urban drainage systems, leading to waterlogging.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

46. Which naturally occurring polymer is completely biodegradable and often used as an eco-friendly alternative to plastics for making disposable cutlery?
(A) Synthetic polypropylene plastic
(B) Expanded polystyrene foam
(C) Starch
(D) Thermosetting bakelite resin

47. "Microplastics" are defined as:
(A) Large plastic debris fragments measuring greater than 50 cm in total length.
(B) Specialized microscopic organisms engineered to consume synthetic plastic waste.
(C) Novel plastic materials that can only be laboratory-synthesized under a microscope.
(D) Plastic particles smaller than 5 mm in size.

48. Identify the incorrect statement regarding the recycling of plastics.
(A) Recycling helps in reducing the volume of solid waste.
(B) Thermoplastics are generally easier to recycle than thermosetting plastics.
(C) During recycling, plastics are completely converted into pure drinking water.
(D) Segregation of different types of plastics is necessary before they are melted together.

49. Chemically, common soaps are defined as:
(A) Calcium or magnesium salts of long-chain fatty acids
(B) Sodium or potassium salts of long-chain fatty acids
(C) Sodium salts of sulfonic acids
(D) Alkyl hydrogen sulfates

50. The chemical process of making soap by the alkaline hydrolysis of fats and oils is called:
(A) Esterification
(B) Polymerisation
(C) Vulcanisation
(D) Saponification

51. During the saponification process, which valuable by-product is obtained along with soap?
(A) Glycerol
(B) Pure ethanol liquid
(C) Concentrated acetic acid
(D) Liquid benzene solvent

52. What is the primary difference between sodium soaps and potassium soaps?
(A) Sodium soaps are structurally softer and dissolve much faster in cold water than potassium soaps.
(B) Potassium soaps are chemically inert and completely fail to produce lather under any environmental condition.
(C) Potassium soaps are softer and used in shaving creams.
(D) Sodium soaps are strictly synthesized for heavy industrial application as solid machinery lubricants.

53. Which two primary raw materials are required for the industrial manufacture of ordinary washing soap?
(A) Vegetable oil and sodium hydroxide
(B) Refining mineral oil and concentrated hydrochloric acid solution
(C) Liquefied petroleum gas fractions and

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concentrated sulfuric acid
(D) Industrial coal tar distillate and solid potassium nitrate compound

54. Match the soap and detergent terminology in List I with their descriptions in List II.
List I: (Terminology)
P. Saponification
Q. Glycerol
R. Stearic acid
S. Sodium chloride
List II: (Descriptions)
1. A common long-chain fatty acid used in soap making
2. Process of forming soap from fats
3. Added to precipitate soap from the solution
4. By-product of soap making
(A) P-4, Q-2, R-3, S-1
(B) P-1, Q-3, R-2, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-2, Q-4, R-1, S-3

55. In the traditional laboratory preparation of soap, why is common salt (NaCl) added to the reaction mixture?
(A) To significantly enhance the volume and foaming capacity of the final soap product
(B) To decrease soap solubility, causing it to precipitate.
(C) To impart a distinctively fresh salty fragrance and aroma to the prepared soap block
(D) To chemically transform the crude organic soap molecules directly into synthetic detergent

56. Transparent soaps are prepared by dissolving the soap in which of the following solvents and then evaporating the excess solvent?
(A) Benzene
(B) Kerosene
(C) Ethanol
(D) Carbon tetrachloride

57. Arrange the following steps in the correct order for the laboratory preparation of soap:
I. Add sodium chloride to the mixture.
II. Heat vegetable oil and sodium hydroxide solution together.
III. Filter to separate the solid soap.
IV. Allow the mixture to cool and soap to precipitate.
Select the correct sequence:
(A) II, I, IV, III
(B) I, II, III, IV
(C) II, IV, I, III
(D) IV, I, II, III

58. Which of the following statements about the soap industry is correct?
(A) Modern soap processes continuously recover glycerol.
(B) The global soap industry relies almost exclusively on crude petrochemicals as primary raw materials.
(C) Commercial soaps are synthesized on a large scale by reacting waste plastic resins with mineral acids.
(D) Industrial soap production plants generate large volumes of highly toxic and radioactive hazardous waste.

59. Shaving soaps contain agents that prevent rapid drying of lather. Which of the following is commonly added for this purpose?
(A) Sodium chloride
(B) Glycerol
(C) Calcium carbonate
(D) Silica

60. Which of the following acids is NOT a fatty acid commonly used in the manufacture of soap?
(A) Stearic acid (saturated fatty acid)
(B) Hydrochloric acid
(C) Palmitic acid (saturated fatty acid)
(D) Oleic acid (unsaturated fatty acid)

61. A soap molecule is described as having a specific structure crucial for its cleansing action. What is this structure?
(A) A hydrophilic head and a hydrophobic tail
(B) A hydrophobic head and a hydrophilic tail
(C) Both head and tail are hydrophobic
(D) Both head and tail are hydrophilic

62. During the cleansing action of soap, which part of the soap molecule attaches itself to the dirt or oil droplet?
(A) The hydrophilic carboxylate head
(B) The ionic sodium counter-ion
(C) The hydrophobic tail
(D) The surrounding polar water molecules

63. The spherical aggregate formed by soap molecules in water, which traps dirt in its center, is known as a:
(A) Polymer
(B) Precipitate
(C) Crystal
(D) Micelle

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64. The basic concept of surface tension relates to:
(A) The physical force that continuously causes a free liquid volume to expand its surface area indefinitely.
(B) The measure of electrical resistance and charge accumulation offered across a liquid surface layer.
(C) The tendency of liquid surfaces to shrink to minimum surface area.
(D) The thermodynamic rate at which volatile liquid molecules evaporate into gas at standard room temperature.

65. What effect does adding soap or detergent have on the surface tension of water?
(A) It significantly increases the surface tension.
(B) It significantly decreases the surface tension.
(C) It has no effect on the surface tension.
(D) It makes the surface tension fluctuate randomly.

66. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Soaps and detergents clean fabrics better when dissolved in warm water compared to cold water.
Reason (R): Warm water has a lower surface tension and increased kinetic energy, allowing better penetration into the fabric.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

67. The process of dispersing one immiscible liquid (like oil) in another (like water) is called:
(A) Emulsification
(B) Chemical saponification
(C) Addition polymerisation
(D) Thermal vulcanisation

68. In the context of washing clothes, what acts as the emulsifying agent that allows oil and water to mix?
(A) The dirt
(B) The fabric
(C) The soap or detergent
(D) The calcium ions in water

69. The formation of foam or lather when soap is agitated in water is caused by:
(A) Trapping air bubbles in a soap film created by reduced surface tension.
(B) The rapid chemical evolution and release of pressurized carbon dioxide gas directly from the soap matrix.
(C) A violent, highly exothermic chemical reaction occurring spontaneously between liquid water and soap ions.
(D) The sudden chemical precipitation of insoluble calcium and magnesium salts throughout the aqueous solution.

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70. Consider the following statements:
Statement I: Water alone cannot wash away oily dirt because oil does not dissolve in water.
Statement II: Soap molecules form micelles around oil droplets, making them form an emulsion in water.
Which of the above statement(s) is/are correct?
(A) Only Statement I
(B) Only Statement II
(C) Both Statement I and Statement II
(D) Neither Statement I nor Statement II

71. Consider the following statements regarding micelle formation:
I. Micelles are formed only above a particular temperature called the Kraft temperature.
II. Micelles form only above a certain concentration called the Critical Micelle Concentration (CMC).
III. In a micelle, the hydrophilic ends are directed towards the center.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

72. Identify the odd one out among the following phenomena that are related to surface tension.
(A) Formation of spherical water drops
(B) Capillary action in narrow tubes
(C) Rusting of an iron nail
(D) Insects walking on the surface of water

73. Which of the following best describes the chemical composition of synthetic detergents?
(A) Sodium or potassium salts of naturally occurring long-chain fatty carboxylic acids
(B) Insoluble calcium or magnesium salts derived from saturated fatty acid chains
(C) Soluble potassium salts formed from essential amino acid compounds

(D) Sodium salts of alkyl benzene sulfonic acids

74. Hard water limits the action of ordinary soap. Hard water contains dissolved salts of:
(A) Calcium and magnesium
(B) Monovalent sodium and potassium ions
(C) Metallic iron and heavy zinc minerals
(D) Elemental copper and silver cations

75. Why does ordinary washing soap fail to produce good lather in hard water?
(A) The active soap molecules rapidly evaporate into gas upon contact with minerals in hard water.
(B) Soap reacts with calcium and magnesium to form insoluble scum.
(C) High mineral content in hard water completely destroys the long hydrocarbon chain of the soap molecule.
(D) Soap dissolves instantaneously in hard water, leaving insufficient time for stable lather formation.

76. The sticky, insoluble substance (scum) formed when soap is used in hard water is chemically:
(A) Soluble inorganic sodium sulfate crystals
(B) Calcium or magnesium fatty acid salts
(C) Unreacted pure solid triglycerides and fats
(D) Precipitated inorganic magnesium carbonate mineral

77. Why are synthetic detergents more effective than soaps in hard water?
(A) Their calcium and magnesium salts are water-soluble and do not form scum.
(B) Synthetic detergents react chemically with hard water to generate additional soluble calcium cations.
(C) Detergent molecules substantially elevate the boiling point temperature of untreated hard water.
(D) Active detergent compounds completely evaporate and neutralize dissolved hard water minerals.

78. Match the characteristics in List I with the correct cleansing agent in List II.
List I: (Characteristics)
P. Forms scum with hard water
Q. Works well in hard water
R. Prepared from animal or plant fats
S. Prepared from petrochemical hydrocarbons
List II: (Cleansing Agents)
1. Soap
2. Detergent
(A) P-2, Q-1, R-2, S-1
(B) P-1, Q-1, R-2, S-2
(C) P-1, Q-2, R-1, S-2
(D) P-2, Q-2, R-1, S-1

79. What is a key difference in the origin of raw materials used for making soaps versus synthetic detergents?
(A) Soaps are derived entirely from petrochemicals, whereas detergents are derived from organic plant oils.
(B) Both cleaning agents are manufactured exclusively from natural plant sources and forest residues.
(C) Both cleaning agents are synthesized exclusively from compressed atmospheric nitrogen and carbon gases.
(D) Soaps come from fats/oils, while detergents come from petrochemicals.

80. Identify the correct pair representing a cleansing agent and its performance in hard water.
(A) Soap - Excellent lather, no precipitation
(B) Synthetic Detergent - Forms thick scum, poor cleansing
(C) Synthetic Detergent - Good lather, remains soluble
(D) Soap - Enhances the hardness of water

81. Because synthetic detergents possess cleansing properties similar to soap but do not contain standard soap molecules, they are sometimes referred to as:
(A) Synthetic hard soaps
(B) Soapless soaps
(C) Insoluble metallic soaps
(D) Heavy petro-soaps

82. What is the most significant practical advantage of using detergents over soaps for laundry purposes in areas with groundwater?
(A) Commercial detergents are universally guaranteed to be 100% biodegradable in nature.
(B) Modern detergent formulations are completely non-toxic and safe for human consumption.
(C) Laundry detergents strictly require boiling hot water in order to activate their cleansing action.
(D) Detergents clean effectively in hard or acidic water.

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83. Identify the incorrect statement regarding hard water and cleaning agents.
(A) Detergents require a much larger quantity than soap to wash clothes in hard water.
(B) Scum clings to washed clothes, making them look dull.
(C) Scum can clog drains and pipes over time.
(D) Hardness in water is primarily due to chlorides, sulfates, and bicarbonates of calcium and magnesium.

84. Which of the following cleaning agents is completely synthetic?
(A) Naturally derived sodium stearate soap compound
(B) Traditional potassium palmitate soap salt
(C) Sodium dodecylbenzenesulfonate
(D) Organic olive-oil based Castile soap

85. The biodegradability of a synthetic detergent is heavily dependent on:
(A) The branching of its hydrocarbon chain.
(B) The precise quantity of artificial fragrance oil added during manufacturing.
(C) The specific color dyes mixed into the dry detergent powder formulation.
(D) The physical dimensions of the exterior cardboard box used for packaging.

86. Non-biodegradable synthetic detergents are a major source of water pollution. What specific environmental problem do they primarily cause in lakes and rivers?
(A) Stratospheric ozone layer depletion over polar regions
(B) Accelerated global warming and atmospheric climate change
(C) Severe localized acid rain precipitation
(D) Foaming in waterways harming aquatic life.

87. Modern "eco-friendly" detergents are manufactured to be highly biodegradable by ensuring that:
(A) Their hydrocarbon chains are highly branched.
(B) Their hydrocarbon chains are linear.
(C) They contain heavy metals such as lead and mercury.
(D) They contain excessive concentrations of phosphates.

88. Many everyday cleaning products, like laundry bleaches, contain chemical agents to remove stains. Which of the following is a common active ingredient in liquid bleach?
(A) Soluble sodium chloride salt
(B) Precipitated calcium carbonate
(C) Sodium hypochlorite
(D) Crystalline ammonium nitrate

89. Match the everyday cleaning chemicals in List I with their common names or functions in List II.
List I: (Chemicals)
P. Sodium carbonate decahydrate
Q. Sodium hypochlorite
R. Sodium hydroxide
S. Sodium bicarbonate
List II: (Common Names/Functions)
1. Baking soda (mild abrasive cleaner)
2. Washing soda
3. Bleaching agent
4. Caustic soda (drain cleaner base)
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-3, R-4, S-1

90. Consider the following statements regarding the environmental impact of detergents:
I. Detergents with highly branched hydrocarbon chains resist degradation by bacteria.
II. Phosphates added to detergents can cause rapid algae growth in lakes (eutrophication).
III. Biodegradable detergents completely solve the problem of hard water scum but increase toxicity.
Which of the above statement(s) is/are correct?
(A) I only
(B) I and II only
(C) II and III only
(D) I, II, and III

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91. What is the primary role of phosphate compounds when they are added to commercial detergent powders?
(A) To function as an aromatic fragrance enhancer in the wash
(B) To soften water by binding calcium and magnesium ions.
(C) To impart a bright blue color to the detergent granules
(D) To significantly increase the flammability of the dry powder

92. Identify the incorrect pair of chemical and its everyday household cleaning use.
(A) Hydrochloric acid - Toilet bowl cleaning

(muriatic acid)
(B) Sulfuric acid - Skin moisturizing
(C) Ammonia - Glass and window cleaning
(D) Acetic acid (Vinegar) - Descaling and mild cleaning

93. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Detergents with highly branched alkyl chains cause severe foaming in rivers and lakes.
Reason (R): Highly branched alkyl chains are easily broken down by bacteria in wastewater treatment plants.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

94. Eutrophication, characterized by dense algal blooms and subsequent depletion of oxygen in water bodies, is frequently caused by which component of washing powders?
(A) Sodium chloride
(B) Glycerol
(C) Phosphates
(D) Silica

95. In the detergent industry, substances called "builders" are often added to washing powders. What is their function?
(A) They construct a durable protective physical layer over textile fibers to repel dirt.
(B) They artificially expand the physical bulk volume of detergent packaging to deceive buyers.
(C) They chemically break down stubborn fabric fibers to temporarily make them feel softer.
(D) They maintain alkalinity and soften water to enhance cleaning.

96. Which is the most appropriate reason to encourage the use of eco-friendly detergents?
(A) They are substantially cheaper and far more economical for chemical factories to manufacture.
(B) They operate through dry chemical action and require zero water to clean dirty clothing.
(C) They degrade rapidly without accumulating or foaming in water.
(D) They generate high thermal energy that automatically irons clothing during the wash cycle.

97. Match the synthetic polymers in List I with their respective monomer units in List II.
List I: (Polymers)
P. Nylon-6
Q. Polyacrylonitrile (Orlon)
R. Polystyrene
S. Polypropene
List II: (Monomers)
1. Propene
2. Styrene
3. Acrylonitrile
4. Caprolactam
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-1, R-3, S-2

98. The chemical name of the polymer widely used as a non-stick coating on frying pans is:
(A) Polymethyl methacrylate polymer
(B) Polyvinyl acetate resin
(C) Polyethylene glycol compound
(D) Polytetrafluoroethylene

99. Select the correct order of the following polymers based on increasing intermolecular forces of attraction.
(A) Elastomers → Plastics → Fibres
(B) Fibres → Plastics → Elastomers
(C) Plastics → Elastomers → Fibres
(D) Elastomers → Fibres → Plastics

100. Orlon, often used as a substitute for wool in making blankets and sweaters, is a polymer of:
(A) Ethene
(B) Vinyl chloride
(C) Acrylonitrile
(D) Isoprene

101. Which polymer is highly resistant to heat and chemical attack, making it suitable for gaskets, pump packings, and non-stick pans?
(A) Teflon
(B) PVC
(C) Polystyrene
(D) Nylon

102. Consider the following statements about vulcanised rubber:
I. It has higher tensile strength than natural rubber.
II. It is highly sticky and soft compared to

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natural rubber.
III. It has a high water absorption capacity.
IV. It resists oxidation better than natural rubber.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) III and IV only
(D) I and IV only

103. In chemistry, the "saponification value" of a fat or oil represents:
(A) The exact thermal melting temperature at which solid soap transitions into a fluid liquid state.
(B) Milligrams of KOH required to saponify one gram of fat.
(C) The precise volume of persistent foam generated by agitating exactly one gram of pure soap.
(D) The total volume of liquid water necessary to fully dissolve one gram of prepared soap block.

104. Match the type of soap in List I with its distinctive ingredient or property in List II.
List I: (Type of Soap)
P. Shaving soap
Q. Transparent soap
R. Medicated soap
S. Floating soap
List II: (Distinctive Ingredient/Property)
1. Contains added antiseptic agents (e.g., neem or dettol)
2. Beaten with tiny air bubbles before hardening
3. Dissolved in ethanol which is then evaporated
4. Contains rosin and glycerol for lasting lather
(A) P-3, Q-4, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-4, S-3

105. Consider the following statements:
Statement I: Nylon-2-nylon-6 is an example of an environmentally friendly, biodegradable polymer.
Statement II: Conventional Nylon-6,6 is highly resistant to biological degradation.
Which of the above statement(s) is/are correct?
(A) Only Statement I
(B) Only Statement II
(C) Both Statement I and Statement II
(D) Neither Statement I nor Statement II

106. Which of the following is an example of a thermosetting plastic?
(A) Melamine resin
(B) High-density polythene polymer
(C) Polyvinyl chloride thermoplastic
(D) Expanded polystyrene plastic

107. The specific compound added to shaving soaps to produce a rich and stable lather is:
(A) Sodium chloride salt
(B) Rosin
(C) Concentrated ethanol solvent
(D) Precipitated calcium carbonate

108. What is commonly added to premium bathing soaps to moisturize the skin and prevent rapid drying?
(A) Sodium hydroxide
(B) Glycerol
(C) Hydrochloric acid
(D) Bleaching powder

109. Plastic items are often labeled with a recycling code (a number inside a triangle). Arrange the following polymers according to their standard recycling codes from 1 to 4:
I. PVC
II. PET (Polyethylene terephthalate)
III. LDPE (Low-density polythene)
IV. HDPE (High-density polythene)
Select the correct sequence (Code 1, 2, 3, 4):
(A) II, IV, I, III
(B) I, II, III, IV
(C) IV, III, II, I
(D) II, I, IV, III

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110. Melamine polymer is widely used in the manufacture of:
(A) Automobile tires
(B) Parachutes
(C) Unbreakable crockery
(D) Transparent wrapping films

111. Natural rubber is chemically defined as:
(A) trans-1,4-polyisoprene
(B) poly-1,3-butadiene
(C) polychloroprene
(D) cis-1,4-polyisoprene

112. The catalyst typically used for the low-pressure manufacture of high-density polythene (HDPE) is called:
(A) Industrial contact process catalyst
(B) Metallic iron Haber process catalyst
(C) Ziegler-Natta catalyst

(D) Palladium-based Lindlar catalyst

113. Rayon is often referred to as artificial silk. Chemically, it is classified as a:
(A) Fully synthetic chemical polymer
(B) Semi-synthetic polymer
(C) Naturally occurring animal protein
(D) Synthetic polyolefin hydrocarbon

114. Match the synthetic polymers in List I with their primary applications in List II.
List I: (Polymers)
P. Polycarbonate
Q. Kevlar
R. Polystyrene
S. Polyurethane
List II: (Applications)
1. Bulletproof vests
2. Foam mattresses and cushions
3. Shatterproof safety glasses and CDs
4. Thermocol packaging and disposable cups
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

115. Which of the following is an example of a cationic detergent, often used in hair conditioners due to its germicidal properties?
(A) Cetyltrimethylammonium bromide
(B) Sodium lauryl sulfate surfactant
(C) Sodium dodecylbenzenesulfonate detergent
(D) Polyethylene glycol stearate compound

116. The most common type of detergent used in household laundry powders is anionic. An example of an anionic detergent is:
(A) Cetyltrimethylammonium bromide
(B) Liquid dishwashing soap (non-ionic)
(C) Sodium lauryl sulfate
(D) Stearic acid

117. Non-ionic detergents do not contain any ions in their constitution. They are prominently used as:
(A) Liquid dishwashing detergents
(B) Heavy-duty solid commercial toilet soaps
(C) Industrial bleaching chemical agents
(D) Inorganic hard water softeners

118. Which statement about surface tension and cleansing action is incorrect?
(A) Pure water has a high surface tension, which prevents it from easily penetrating fabrics.
(B) Detergents lower the surface tension of water, facilitating the wetting of fabrics.
(C) The hydrophobic tails of soap molecules avoid water, aligning at the surface and reducing surface tension.
(D) Soaps increase the surface tension of water, allowing it to act like a sharp knife to cut dirt.

119. Among the following options, identify the polymer that is biodegradable.
(A) Nylon-6,6
(B) Nylon-2-nylon-6
(C) Polyvinyl Chloride
(D) Polystyrene

120. During the cleansing action of soap, the micelles remain suspended in the water and do not come together to precipitate out. This happens because the micelles form a stable:
(A) True solution
(B) Suspension
(C) Colloid
(D) Saturated solution

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ANSWERS

1. (B) Monomer
Polymers are high molecular weight macromolecules formed by joining a vast number of small, simple repeating structural units known as monomers. Monomers undergo chemical bonding through a process termed polymerisation to produce long polymer chains. Understanding monomers is essential in material science because their specific chemical structure determines the overall physical and chemical properties of the resulting polymer.

2. (D) The chemical combination of many small molecules to form a large macro-molecule
Polymerisation is a chemical reaction in which a large number of relatively small molecules, called monomers, combine chemically to form a very large chainlike or network macromolecule called a polymer. This process involves forming covalent bonds between monomers, which can occur via addition or condensation mechanisms depending on the functional groups present in the starting monomer molecules.

3. (A) Cellulose
Cellulose is a naturally occurring structural carbohydrate polymer synthesized by plants to provide rigidity and mechanical strength to their cell walls. It consists of a long chain of repeating glucose monomer units linked together by glycosidic bonds. Unlike synthetic polymers like polythene, nylon, and polyvinyl chloride, cellulose is fully biodegradable and sourced directly from natural organic vegetation.

4. (C) Proteins
Silk is a natural protein fiber produced by silkworms, primarily composed of the structural protein fibroin. Proteins are biopolymers made of long amino acid chains linked together by peptide bonds. Silk possesses high tensile strength, lustrous appearance, and smooth texture due to the organized antiparallel beta-sheet structures formed within its underlying polypeptide molecular chains during natural biological secretion.

5. (A) Isoprene
Natural rubber is an organic polymer formed through the natural biological addition polymerisation of 2-methyl-1,3-butadiene, commonly known as isoprene. Repeating isoprene units align predominantly in a cis-1,4 configuration to give natural rubber its characteristic flexibility and elasticity. Processing natural rubber from tree latex allows for various industrial applications, although unvulcanised rubber remains sensitive to temperature variations.

6. (D) Glycogen - Cotton fibers
Glycogen is a naturally occurring polysaccharide polymer that serves as the primary energy storage molecule in animals and human liver or muscle tissues, whereas cotton fibers consist almost entirely of cellulose obtained from plant sources. Cellulose provides structural support to plant walls, while glycogen functions strictly as a branched glucose reservoir within animal systems for energy metabolic regulation.

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7. (B) P-4, Q-3, R-2, S-1
Polythene is synthesized through the addition polymerisation of ethene monomers. Polyvinyl chloride is produced from vinyl chloride monomers. Teflon, known chemically as polytetrafluoroethylene, is formed from tetrafluoroethene monomers. Natural rubber is an organic elastomer composed of repeating isoprene units. Matching each specific polymer to its corresponding monomer unit is fundamental in polymer chemistry and material science applications.

8. (C) Both Statement I and Statement II
Addition polymerisation involves unsaturated monomers containing double or triple bonds linking together repeatedly without forming any chemical by-products. Conversely, condensation polymerisation occurs when monomers with multiple functional groups combine with the simultaneous elimination of small simple molecules like water, alcohol, or hydrogen chloride. Both chemical descriptions accurately define these fundamental categories of polymer formation pathways.

9. (D) They are exclusively composed of amino acid monomers.
Synthetic polymers are human-made materials produced industrially from petrochemical derivatives rather than amino acid monomers. Polymers composed exclusively of amino acid units are natural proteins. Synthetic polymers include plastics, synthetic fibers, and elastomers, which exhibit strong resistance to environmental degradation, distinct thermal properties, and high durability, making them suitable for widespread industrial and consumer everyday applications.

10. (A) Nylon
Nylon is a fully synthetic polyamide fiber manufactured chemically in laboratories from petrochemical precursors without using natural biological raw materials. In contrast, cotton, jute, and wool are naturally occurring polymers obtained directly from plants or animal sources. Nylon differs fundamentally from natural fibers due to its synthetic origin, superior tensile strength, abrasion resistance, and low moisture absorption properties.

11. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Cellulose is categorized as a natural polymer because it is synthesized naturally within living plants without human industrial intervention. Plant cells produce cellulose through the condensation polymerisation of beta-D-glucose monomer units, creating linear chains that provide structural integrity and strength to cell walls. Thus, the biological origin and condensation mechanism directly justify its natural polymer classification.

12. (B) Lightweight, durable, and chemically unreactive
Polythene and other synthetic polymers are extensively utilized in consumer products primarily because they offer exceptional physical durability, low density, ease of molding, and strong chemical inertness. Their resistance to atmospheric corrosion, water degradation, and chemical oxidation ensures a long service life across diverse application areas including packaging, containers, household items, and industrial piping systems.

13. (A) Polyvinyl Chloride
The acronym PVC stands for polyvinyl chloride, a widely used synthetic thermoplastic polymer derived from the polymerisation of vinyl chloride monomers. PVC is recognized for its high physical strength, chemical durability, flame resistance, and versatility. It can be formulated with plasticizers into flexible materials or processed without additives to manufacture rigid, heavy-duty building and construction products.

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14. (C) Polyvinyl chloride polymer
Polyvinyl chloride is extensively used for manufacturing rigid water pipes, electrical cable insulation, and conduits. Its strong resistance to chemical corrosion, moisture penetration, and electrical current, combined with high mechanical durability and low cost, makes it an ideal engineering material for domestic plumbing systems, urban drainage networks, and safe electrical wire jacketing in building infrastructure.

15. (D) Polyamide
Nylon-6,6 is classified chemically as a polyamide polymer because its linear molecular chain is linked repeatedly by amide bonds formed during condensation polymerisation. It is synthesized by reacting hexamethylenediamine with adipic acid, eliminating water molecules. The recurring amide linkages facilitate strong intermolecular hydrogen bonding, conferring exceptional tensile strength, toughness, elasticity, and thermal stability upon nylon fibers.

16. (C) Polyethylene terephthalate
PET stands for polyethylene terephthalate, a major synthetic polyester polymer prepared by the condensation reaction of ethylene glycol with terephthalic acid. Possessing excellent clarity, strength, moisture barrier properties, and shatter resistance, PET is widely used to manufacture lightweight beverage bottles, food storage containers, synthetic clothing fibers, and various durable packaging films in global commercial industries.

17. (B) They resist wrinkling and are easy to wash.
Polyester fibers are synthetic polymers characterized by high dimensional stability, wrinkle resistance, rapid drying capabilities, and resistance to shrinking. These properties stem from the hydrophobic nature of polyester molecules and strong chemical bonds within the

polymer chain. As a result, polyester fabrics retain their shape, require minimal thermal ironing, and endure repeated laundry washing cycles without significant wear.

18. (D) It is a classic example of a thermosetting polymer.
Polythene is a thermoplastic polymer, not a thermosetting polymer, meaning it can be repeatedly softened by heating and hardened by cooling without permanent chemical degradation. It is produced by the addition polymerisation of ethene gas. Low-density polythene features extensive chain branching, while high-density polythene consists of linear polymer chains synthesized using specialized Ziegler-Natta coordination catalysts.

19. (A) LDPE has branched chains, while HDPE has linear chains.
Low-density polythene possesses highly branched polymer chains that prevent tight structural packing, resulting in a flexible, lower-density material. High-density polythene consists primarily of unbranched linear chains that pack closely together, creating a rigid, highly crystalline material with greater tensile strength, density, and melting temperature. Both forms are produced from ethene monomers under distinct catalytic reaction conditions.

20. (B) I and III only
Nylon was the first fully synthetic fiber created entirely from coal, water, and air without using plant or animal raw materials. Nylon fibers are exceptionally strong, elastic, and durable. Polyester fabrics possess high wrinkle resistance and dimensional stability. Combining nylon's historical synthetic origin with polyester's crease-resistant textile qualities highlights key functional advantages of modern synthetic polymeric fibers.

21. (A) To combine cotton's breathability with polyester's durability
Blending polyester with natural cotton to create polycot produces a hybrid textile that merges the favorable physical properties of both fibers. Cotton provides soft feel, comfort, and breathability, while polyester imparts high tensile strength, crease resistance, tear resistance, and shape retention. This combination yields a comfortable, durable, easily washable, and long-lasting fabric suitable for daily apparel.

22. (D) Teflon - Non-stick coating on cookware
Teflon, chemically known as polytetrafluoroethylene, features extremely strong carbon-fluorine bonds that confer exceptional heat resistance, chemical inertness, and a low coefficient of friction. These unique surface properties make Teflon an ideal material for non-stick coatings on cookware, industrial gaskets, and corrosion-resistant linings. Other polymers serve different functional roles, such as Bakelite in electrical switches and melamine in dinnerware.

23. (B) It involves heating ethene under pressure with an initiator.
The commercial manufacture of polythene involves the addition polymerisation of ethene gas carried out under elevated pressure and elevated temperature conditions in the presence of trace oxygen or peroxide initiators. This free-radical addition mechanism causes ethene double bonds to open and repeatedly join together, forming long-chain hydrocarbon macromolecules suitable for flexible or rigid plastic product manufacturing.

24. (C) Acrylic
Acrylic fiber, synthesized from polyacrylonitrile, serves as an economical synthetic alternative to natural wool due to its soft, warm, lightweight, and resilient nature. It effectively mimics the thermal insulation, drape, and texture of natural wool while offering superior resistance to moth damage, chemical degradation, shrinking, and outdoor weathering, making it popular for sweaters, blankets, and winter wear.

25. (D) Thermoplastics can be remelted, while thermosetting plastics set permanently.
Thermoplastics consist of linear or branched polymer chains held by weak intermolecular forces, enabling them to repeatedly soften upon heating and harden upon cooling. In contrast, thermosetting plastics undergo irreversible chemical cross-linking during initial thermal molding, creating a rigid three-dimensional network. Consequently, thermosetting plastics retain their fixed shape permanently and decompose rather than remelt when subjected to intense subsequent heating.

26. (A) Bakelite
Bakelite, or phenol-formaldehyde resin, is a classic thermosetting polymer formed via

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condensation polymerisation. During thermal molding, extensive cross-linking creates a hard, rigid, three-dimensional network structure. Once set, Bakelite cannot be remelted or reshaped by heating. Its high heat resistance and excellent electrical insulating properties make it ideal for manufacturing electrical switches, appliance handles, and automobile components.

27. (B) They form 3D cross-links between polymer chains when molded.
Thermosetting plastics fail to soften upon heating after initial molding because the molding process induces permanent chemical reactions that form dense three-dimensional covalent cross-links between adjacent polymer chains. This rigid network locks the macromolecular structure in place, preventing polymer chains from sliding past one another when thermal energy is applied, causing thermal degradation instead of melting.

28. (B) Bakelite
Bakelite is widely used for manufacturing electrical switches, plugs, sockets, and switchboards because it is an excellent thermal and electrical insulator. As a thermosetting phenol-formaldehyde polymer, Bakelite maintains structural rigidity and mechanical strength even when subjected to electric sparks or high operational temperatures, ensuring safe long-term performance without melting or conducting electric current.

29. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Polyvinyl chloride is correctly classified as a thermoplastic polymer because it consists of linear chains with weak intermolecular forces that allow reversible physical changes upon temperature variation. Heating PVC softens the material into a moldable state, and cooling hardens it into shape without breaking covalent bonds within the main chain. This reversible thermal behavior defines the fundamental characteristic of thermoplastics.

30. (C) Neoprene
Neoprene, chemically known as polychloroprene, is a synthetic rubber produced by the polymerisation of 2-chloro-1,3-butadiene monomers. It exhibits high chemical stability, oil resistance, thermal tolerance, and flexibility over a wide temperature range. Unlike natural rubber or natural biopolymers like cellulose and glycogen, neoprene is manufactured industrially to serve as an elastomer for industrial hoses, wet suits, and gaskets.

31. (D) Sulfur
Vulcanisation is a chemical process where raw natural rubber is heated with elemental sulfur and suitable additives. Sulfur forms cross-linked chemical bridges between individual polyisoprene polymer chains at double bond reaction sites. This cross-linking fundamentally modifies the structural network of the elastomer, turning soft, tacky natural rubber into a tough, elastic, temperature-resistant, and durable commercial material.

32. (C) To increase its tensile strength and elasticity.
The primary purpose of vulcanising natural rubber is to enhance its mechanical performance, tensile strength, structural elasticity, and thermal stability. Raw natural rubber is sticky when warm, brittle when cold, and susceptible to water absorption. Heating rubber with sulfur introduces chemical cross-links that prevent polymer chain slippage, dramatically improving wear resistance and mechanical elasticity for commercial applications.

33. (B) P-4, Q-3, R-2, S-1
Polystyrene is a thermoplastic that can be repeatedly softened by heating. Melamine is a rigid thermosetting plastic used in durable dinnerware. Natural rubber is an elastomer obtained directly from latex. Buna-S is a synthetic elastomer produced by copolymerizing 1,3-butadiene with styrene. Accurately matching polymer classes with representative examples highlights their distinct physical structures and processing behaviors.

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34. (D) Natural rubber comes from tree latex, while synthetic rubber comes from petrochemicals.
Natural rubber is harvested as a milky liquid emulsion called latex directly from rubber trees like Hevea brasiliensis, whereas synthetic rubbers such as Buna-S, Buna-N, and neoprene are synthesized artificially from petrochemical hydrocarbon raw materials. Synthetic rubbers are specifically engineered in chemical facilities to offer targeted resistance to oil, heat, weathering, and mechanical abrasion compared to raw natural rubber.

35. (A) 1,3-Butadiene and Styrene
Buna-S is a widely used synthetic elastomer produced by the copolymerisation of 1,3-butadiene and styrene in a specific ratio under controlled conditions. The designation "Buna" derives from butadiene and sodium catalyst, while "S" represents styrene. Buna-S exhibits superior abrasion resistance, toughness, and aging stability, making it highly suitable for automobile tire treads, footwear soles, and conveyor belting.

36. (C) Cross-links at double bond sites.
During the vulcanisation process, added sulfur atoms react chemically at reactive double bond locations along polyisoprene chains to create strong disulfide or polysulfide cross-links. These short sulfur bridges lock adjacent polymer chains together into a three-dimensional network. This cross-linking prevents chain slippage during mechanical stretching, significantly increasing the rubber's elasticity, tensile strength, and heat tolerance.

37. (A) Unbreakable crockery
Melamine formaldehyde resin is a thermosetting polymer widely used in manufacturing unbreakable dinnerware, plates, cups, and trays. Melamine exhibits remarkable hardness, surface shine, flame retardancy, and high thermal resistance compared to standard thermoplastics. These physical properties enable melamine crockery to resist scratching, structural deformation, and chemical stain damage during daily domestic kitchen and catering handling.

38. (D) They persist in nature, causing environmental pollution.
The primary environmental concern associated with synthetic plastics is their high persistence and non-biodegradable nature. Because microorganisms lack enzymes capable of breaking down synthetic carbon-carbon polymer backbones, discarded plastic items accumulate in landfills, terrestrial ecosystems, and marine environments for centuries. This persistent accumulation leads to ecological degradation, wildlife choking hazards, and microplastic contamination across global ecosystems.

39. (B) PHBV
PHBV, chemically known as poly(hydroxybutyrate-co-hydroxyvalerate), is a biodegradable synthetic polyester polymer produced by bacterial fermentation or chemical copolymerisation. Unlike conventional synthetic plastics such as PVC, Teflon, or HDPE, PHBV contains ester bonds vulnerable to enzymatic cleavage by environmental microorganisms, breaking down into natural harmless molecules like water, carbon dioxide, and biomass.

40. (B) Collection → Sorting → Cleaning → Melting → Pelletizing
The standard mechanical recycling process for plastic waste follows a systematic chronological sequence starting with initial waste collection from consumers. Collected plastics are sorted by resin type and cleaned to remove dirt, labels, and chemical contaminants. The cleaned plastic material is subsequently melted down and extruded into small standardized plastic pellets used as recycled raw feedstock for manufacturing.

41. (D) Reduce, Reuse, Recycle
The 3R principle stands for Reduce, Reuse, and Recycle, forming a foundational framework for sustainable waste management and environmental conservation. Reducing plastic consumption minimizes waste generation at the source, reusing plastic products extends their operational lifespan before disposal, and recycling converts post-consumer plastic waste into reusable raw materials, collectively conserving natural resources and lowering environmental pollution.

42. (A) Cannot be decomposed by natural biological processes in the environment.
A polymer is classified as non-biodegradable when naturally occurring biological agents, such as bacteria, fungi, and environmental enzymes, are incapable of degrading its chemical structure over time. Most synthetic thermoplastics possess strong hydrophobic carbon-carbon backbone linkages that resist enzymatic degradation, causing these materials to persist unchanged in terrestrial and aquatic ecosystems for hundreds of years.

43. (B) Source segregation, recycling, and safe disposal
Managing non-biodegradable plastic waste effectively requires systematic source segregation, extensive material recycling, and controlled safe disposal methods. Segregating plastic waste at the point of origin streamlines mechanical sorting, enabling higher recovery rates for

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recyclables. Implementing proper recycling practices reduces raw material extraction, while contained, engineered landfill disposal prevents toxic chemical leaching and environmental pollution.

44. (B) They produce toxic hydrogen chloride fumes.
Burning chlorine-containing synthetic polymers like polyvinyl chloride in open unlined environments causes incomplete thermal combustion and dangerous chemical decomposition. This process releases toxic hydrogen chloride gas alongside hazardous organochlorine by-products, including dioxins and furans. Inhaling these corrosive gaseous emissions poses severe human health risks, damages lung tissues, and causes significant atmospheric air pollution.

45. (D) I, II, and III
Plastic pollution creates multiple environmental hazards across various biological systems. Marine organisms frequently ingest plastic debris, suffering internal physical blockages, choking, and death. Accumulated microplastics disrupt soil structure and soil microbial communities, affecting agricultural crop yields. Furthermore, discarded non-biodegradable urban plastic waste obstructs municipal storm drainage systems, triggering severe localized flooding and waterlogging during monsoon seasons.

46. (C) Starch
Starch is a naturally occurring plant polysaccharide polymer that is completely biodegradable and environmentally benign. Because it can be converted into natural bioplastics or processed directly into compostable items, starch serves as an eco-friendly substitute for petroleum-based single-use synthetic plastics in producing disposable cutlery, food containers, packaging films, and biodegradable agricultural mulching sheets.

47. (D) Plastic particles smaller than 5 mm in size.
Microplastics are defined as tiny synthetic plastic particles measuring less than five millimeters in length or diameter. They originate either from commercial primary manufacturing micro-beads used in cosmetics or from secondary physical degradation of larger plastic debris like bottles, bags, and synthetic textiles. Due to their small dimensions, microplastics easily infiltrate food chains and aquatic environments.

48. (C) During recycling, plastics are completely converted into pure drinking water.
Synthetic plastics consist of complex organic carbon polymers and cannot be converted into pure drinking water during recycling processes. Mechanical recycling reprocesses spent polymers through physical melting and re-pelletization. Thermoplastics are generally easier to recycle than thermosetting resins, waste segregation remains essential for material purity, and proper recycling significantly reduces solid municipal landfill accumulation worldwide.

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49. (B) Sodium or potassium salts of long-chain fatty acids
Chemically, ordinary soaps are defined as the sodium or potassium salts of long-chain aliphatic carboxylic acids, commonly known as fatty acids. These fatty acids typically contain twelve to eighteen carbon atoms per molecule, such as stearic, palmitic, or oleic acid. The ionic hydrophilic carboxylate head and long non-polar hydrophobic hydrocarbon chain enable soap's surfactant and cleansing actions.

50. (D) Saponification
Saponification is the chemical reaction involved in making soap, defined as the alkaline hydrolysis of naturally occurring fats and oils using aqueous sodium or potassium hydroxide. Hydrolysis breaks ester bonds within triglyceride molecules, yielding free carboxylate salts that constitute soap, alongside glycerol as a valuable chemical byproduct. This process represents the fundamental basis of traditional soap production.

51. (A) Glycerol
During the saponification process, glycerol, chemically known as propane-1,2,3-triol, is produced as a major byproduct alongside soap. When aqueous alkali hydrolyzes the triglyceride ester bonds of vegetable oils or animal fats, glycerol splits off into the reaction solution. Industrial soap operations purify and recover this valuable byproduct for use in pharmaceuticals, cosmetics, and foods.

52. (C) Potassium soaps are softer and used in shaving creams.
Potassium soaps are synthesized using potassium hydroxide, yielding products that are softer, more water-soluble, and smoother on human skin compared to sodium soaps. These properties make potassium soaps ideal for formulating

shaving creams, liquid soaps, body washes, and specialty cosmetics. In contrast, sodium soaps are firmer solid cakes typically used as standard laundry or toilet bars.

53. (A) Vegetable oil and sodium hydroxide
The industrial manufacture of standard solid washing soap primarily requires natural vegetable oils or animal fats combined with strong sodium hydroxide solution. The triglycerides present in natural plant fats undergo basic hydrolysis when heated with sodium hydroxide, generating solid sodium fatty acid carboxylate salts that form functional soap, while yielding glycerol as a valuable chemical coproduct.

54. (D) P-2, Q-4, R-1, S-3
Saponification is the chemical process of forming soap from fats upon alkaline treatment. Glycerol serves as a trihydroxy alcohol coproduct generated during fat cleavage. Stearic acid is a representative eighteen-carbon saturated fatty acid widely used in soap making. Sodium chloride is added at the conclusion of saponification to reduce soap solubility and precipitate solid soap products.

55. (B) To decrease soap solubility, causing it to precipitate.
In the laboratory preparation of soap, common salt is added to the hot reaction mixture to induce precipitation through the common-ion effect. Adding sodium ions increases total solution ionic strength, drastically lowering the solubility of sodium fatty acid carboxylate salts. This forces the dissolved soap to separate out as a solid floating layer, facilitating filtration and recovery.

56. (C) Ethanol
Transparent soaps are manufactured by dissolving crude prepared soap cakes in ethanol solvent, filtering out insoluble inorganic impurities, and subsequently evaporating the excess alcohol solvent under controlled conditions. This processing leaves behind a clear, translucent solid soap matrix with uniform optical clarity. Glycerol or sugar syrup is often added to enhance the final clarity and cosmetic appeal.

57. (A) II, I, IV, III
The correct laboratory procedure for soap preparation begins by heating vegetable oil with aqueous sodium hydroxide to induce saponification. Sodium chloride is then added to the hot mixture to decrease soap solubility via the common-ion effect. Allowing the reaction mixture to cool causes solid soap to precipitate completely, which is finally filtered and separated from the liquid.

58. (A) Modern soap processes continuously recover glycerol.
Modern industrial soap manufacturing operations continuously recover glycerol generated during the alkaline hydrolysis of natural fats and oils. Glycerol is a valuable chemical co-product purified for high-value applications in pharmaceutical formulations, food processing, cosmetics, and personal care products, enhancing the overall economic efficiency and environmental sustainability of commercial soap manufacturing plants worldwide.

59. (B) Glycerol
Glycerol is added to shaving soap formulations to act as a humectant and plasticizer, preventing the generated lather from drying rapidly on human skin during shaving. It absorbs moisture from the atmosphere and retains water within the soap foam structure. Additionally, shaving soaps contain rosin to produce abundant, creamy, and long-lasting lather for smoother razor gliding.

60. (B) Hydrochloric acid
Hydrochloric acid is a strong, inorganic mineral acid that contains no organic hydrocarbon chains and cannot form soap. Soap manufacturing requires long-chain organic fatty carboxylic acids containing twelve to eighteen carbon atoms, such as saturated stearic acid, saturated palmitic acid, or unsaturated oleic acid. These fatty acids undergo basic neutralization or alkaline hydrolysis to form cleansing carboxylate salts.

61. (A) A hydrophilic head and a hydrophobic tail
A soap molecule possesses an amphiphilic dual structure containing a polar hydrophilic carboxylate ionic head and a non-polar hydrophobic hydrocarbon chain tail. The ionic head interacts strongly with polar water molecules through dipole attraction, while the non-polar alkyl tail repels water and readily dissolves in non-polar grease, oil, and dirt droplets, driving surfactant action during cleaning operations.

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62. (C) The hydrophobic tail
During the cleansing process, the non-polar hydrophobic hydrocarbon tail of the soap molecule dissolves directly into non-polar oily dirt or grease droplets. Meanwhile, the polar hydrophilic ionic head points outward into the surrounding bulk aqueous solution. This specific orientation allows soap molecules to encapsulate oil droplets, detaching dirt from fabric surfaces and enabling easy rinse removal with water.

63. (D) Micelle
A micelle is a spherical colloidal aggregate formed spontaneously by surfactant molecules like soap in aqueous solutions. The hydrophobic non-polar hydrocarbon tails cluster together inwardly to sequester oil and grease inside the core, while the hydrophilic polar ionic heads extend outward into surrounding water molecules. This micellar arrangement traps dirt within its interior, facilitating emulsification and washing.

64. (C) The tendency of liquid surfaces to shrink to minimum surface area.
Surface tension is a physical property of liquids caused by cohesive intermolecular attractive forces pulling surface molecules inward toward the bulk liquid. This cohesive inward force creates a state of mechanical tension across the exposed liquid boundary, causing the free liquid surface to act like an elastic membrane and naturally shrink to attain the smallest possible surface area.

65. (B) It significantly decreases the surface tension.
Adding soap or detergent to water significantly reduces its surface tension. Surfactant molecules concentrate at the water surface, where their hydrophobic tails disrupt cohesive hydrogen bonding between adjacent water molecules. Lowering surface tension allows water to spread out more effectively, increase surface wetting capability, penetrate fine fabric pores deeply, and dislodge stubborn oily soil particles during washing.

66. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Soaps and detergents clean fabrics more effectively in warm water because elevated temperatures reduce water's surface tension and increase kinetic energy among molecules. Lower surface tension enables enhanced wetting and deeper solution penetration into textile fibers, while increased kinetic energy accelerates micellar dispersion and the thermal dissolution of solid grease, directly explaining the improved cleaning performance observed.

67. (A) Emulsification
Emulsification is the physical process of dispersing one immiscible liquid into another in the form of fine, stable droplets. Because oil and water are naturally immiscible, stirring them creates an unstable mixture that quickly separates. Adding an emulsifying agent like soap lowers interfacial tension, stabilizing oil droplets within the water phase and preventing coalescence into a separate layer.

68. (C) The soap or detergent
Soap or detergent functions as an emulsifying agent during laundry washing by bridging the interface between immiscible oil and water. The non-polar hydrophobic tails insert into greasy dirt droplets while polar hydrophilic heads interact with bulk water. This arrangement forms stable colloidal micellar emulsions, suspending oily soil in the water bath so it can be thoroughly rinsed away.

69. (A) Trapping air bubbles in a soap film created by reduced surface tension.
Agitating a soap solution in water generates lather or foam as reduced surface tension enables thin liquid films to stretch without breaking easily. Mechanical agitation incorporates ambient air into the solution, trapping tiny air bubbles within stable aqueous soap films. The surfactant heads stabilize these thin liquid walls surrounding air pockets, maintaining persistent surface lather during cleaning.

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70. (C) Both Statement I and Statement II
Water alone cannot remove oily dirt because polar water and non-polar oil are immiscible due to differing intermolecular forces. Soap resolves this problem because its amphiphilic molecules aggregate around oil droplets, forming micellar structures that create a stable oil-in-water emulsion. Consequently, greasy soil becomes suspended throughout the bulk liquid and is easily carried away during rinsing.

71. (A) I and II only
Micelle formation in surfactant solutions occurs only above a specific temperature, known as the Krafft temperature, and above a minimum

surfactant concentration called the Critical Micelle Concentration. Within a formed micelle, the non-polar hydrophobic alkyl tails direct inward toward the center to avoid water, while the polar hydrophilic heads point outward into the bulk solvent.

72. (C) Rusting of an iron nail
Rusting of an iron nail is a chemical oxidation process involving iron, moisture, and oxygen to form hydrated iron oxide, unrelated to surface tension. Conversely, the formation of spherical water drops, capillary action in narrow tubes, and water strider insects walking on water surfaces are physical phenomena driven directly by liquid surface tension and cohesive intermolecular attraction forces.

73. (D) Sodium salts of alkyl benzene sulfonic acids
Synthetic detergents are chemically defined as sodium salts of long-chain alkyl benzene sulfonic acids or alkyl hydrogen sulfates. Unlike traditional soaps derived from natural fatty acids, synthetic detergents feature modified polar head groups and hydrocarbon chains derived from petroleum fractions, enabling high solubility, strong surfactant behavior, and excellent cleansing action without forming scum in hard water.

74. (A) Calcium and magnesium
Hard water is defined by the presence of dissolved divalent mineral cations, predominantly calcium and magnesium ions present as hydrogen carbonates, chlorides, or sulfates. These dissolved metallic cations react chemically with ordinary sodium fatty acid soaps, forming insoluble precipitates that hinder lather formation and deposit sticky residue on washed fabrics and household plumbing surfaces.

75. (B) Soap reacts with calcium and magnesium to form insoluble scum.
Ordinary soap fails to produce adequate lather in hard water because its soluble sodium or potassium carboxylate salts react instantaneously with dissolved calcium and magnesium ions. This double displacement reaction converts soluble soap into insoluble calcium and magnesium fatty acid carboxylate precipitates, known as scum, consuming active surfactant molecules and reducing cleansing efficiency until mineral ions precipitate.

76. (B) Calcium or magnesium fatty acid salts
The sticky insoluble scum formed when soap encounters hard water consists chemically of insoluble calcium or magnesium salts of long-chain fatty acids. Divalent calcium and magnesium cations replace monovalent sodium or potassium ions in the soap structure, yielding water-insoluble precipitate complexes. This curd-like scum adheres to fabric surfaces, dulls textile colors, and clogs drain pipes.

77. (A) Their calcium and magnesium salts are water-soluble and do not form scum.
Synthetic detergents remain effective in hard water because their calcium and magnesium salts, such as calcium alkyl benzene sulfonate, are fully soluble in water. Unlike conventional fatty acid soaps, synthetic sulfonate and sulfate detergent ions do not form insoluble scum precipitates with hard water mineral cations, allowing detergent molecules to maintain surfactant concentration and lathering action.

78. (C) P-1, Q-2, R-1, S-2
Soaps form insoluble scum precipitates when combined with hard water minerals and are synthesized from natural vegetable or animal fatty triglycerides. Synthetic detergents perform effectively in both soft and hard water without scum formation and are synthesized using petroleum-derived hydrocarbon raw materials. Correctly pairing these features distinguishes traditional soap chemistry from modern synthetic detergent technology.

79. (D) Soaps come from fats/oils, while detergents come from petrochemicals.
A fundamental difference between soaps and synthetic detergents lies in their primary raw material sources. Traditional soaps are manufactured by hydrolyzing naturally occurring animal fats or vegetable oils rich in fatty acid triglycerides. In contrast, synthetic detergents are produced from petrochemical hydrocarbons derived from crude oil refining, such as alkylated benzene derivatives and long-chain petroleum alkenes.

80. (C) Synthetic Detergent - Good lather, remains soluble
Synthetic detergents perform exceptionally well in hard water conditions by maintaining high water solubility and generating abundant lather without forming insoluble precipitates. Divalent

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calcium and magnesium cations present in hard water do not form insoluble complexes with sulfonate or sulfate detergent heads, allowing surfactant molecules to remain dissolved and deliver consistent cleaning performance on soiled laundry.

81. (B) Soapless soaps
Synthetic detergents are often referred to as "soapless soaps" because they display cleansing properties and micellar surfactant behavior similar to traditional soaps without containing carboxylate soap salts. Built from synthetic sulfonate or sulfate hydrophilic head groups attached to petrochemical hydrocarbon tails, they achieve efficient soil emulsification and washing performance without suffering performance degradation in hard water.

82. (D) Detergents clean effectively in hard or acidic water.
The major practical advantage of using synthetic detergents for household laundry in groundwater areas is their ability to clean effectively in hard or acidic water. Groundwater frequently contains high concentrations of dissolved calcium and magnesium salts or acidic components. Detergents remain soluble without forming sticky scum precipitates, ensuring consistent washing efficiency and fabric protection.

83. (A) Detergents require a much larger quantity than soap to wash clothes in hard water.
The statement that detergents require a larger quantity than soap in hard water is incorrect. Soaps react with hard water cations to form insoluble scum, requiring large amounts before lathering occurs. In contrast, synthetic detergents remain soluble in hard water, meaning smaller quantities are needed to achieve lather and thorough cleansing without wasting product.

84. (C) Sodium dodecylbenzenesulfonate
Sodium dodecylbenzenesulfonate is a completely synthetic anionic detergent synthesized from petroleum-derived alkylbenzene precursor molecules. Unlike natural fatty acid carboxylate soaps such as sodium stearate, potassium palmitate, or olive-oil based Castile soaps obtained from vegetable or animal lipids, sodium dodecylbenzenesulfonate features a synthetic sulfonate polar head group tailored for superior stability in hard water applications.

85. (A) The branching of its hydrocarbon chain.
The biological degradability of a synthetic detergent depends on the chemical branching of its non-polar hydrocarbon chain. Highly branched hydrocarbon chains resist enzymatic attack by environmental bacteria, preventing natural breakdown in wastewater treatment plants and aquatic ecosystems. Conversely, detergents engineered with linear hydrocarbon chains are readily digested by microorganisms, making them environmentally safe and biodegradable.

86. (D) Foaming in waterways harming aquatic life.
Non-biodegradable synthetic detergents containing branched hydrocarbon chains resist bacterial breakdown, persisting in municipal wastewater effluents. When discharged into natural rivers, lakes, and streams, accumulated detergent residues create thick surface foam layers. This foam blocks atmospheric oxygen dissolution, reduces sunlight penetration, disrupts aquatic gas exchange, and harms fish, plants, and aquatic organisms across river ecosystems.

87. (B) Their hydrocarbon chains are linear.
Modern eco-friendly synthetic detergents are designed to be highly biodegradable by ensuring their non-polar hydrocarbon tails consist of unbranched linear carbon chains. Soil and aquatic microorganisms easily decompose linear alkyl chains via metabolic pathways, preventing persistent chemical accumulation and excessive foaming in natural waterways while maintaining excellent domestic soil removal and surfactant capabilities.

88. (C) Sodium hypochlorite
Sodium hypochlorite is the active chemical agent in common liquid household laundry bleaches. Functioning as a strong oxidizing agent, sodium hypochlorite releases active chlorine species in aqueous solution, which react chemically with chromophore groups in organic stains, converting colored soil compounds into colorless soluble derivatives and disinfecting fabrics by killing bacteria and viruses during washing.

89. (D) P-2, Q-3, R-4, S-1
Sodium carbonate decahydrate is known as washing soda and acts as a water softener. Sodium hypochlorite functions as a liquid bleaching agent. Sodium hydroxide, or caustic soda, is a strong alkaline base used in heavy-duty drain

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cleaners. Sodium bicarbonate, commonly called baking soda, serves as a mild abrasive cleaner and odor-neutralizing household agent.

90. (B) I and II only
Detergents containing highly branched hydrocarbon chains resist bacterial decomposition, leading to environmental persistence. Polyphosphate builders added to laundry powders act as plant nutrients when discharged into lakes, triggering explosive algal growth termed eutrophication, which depletes dissolved oxygen upon plant decay. Statement III is incorrect because biodegradable detergents eliminate toxicity risks rather than increasing environmental hazards.

91. (B) To soften water by binding calcium and magnesium ions.
Phosphate compounds, such as sodium tripolyphosphate, are added to laundry powders as chemical builders to soften wash water. Phosphates sequester dissolved divalent calcium and magnesium cations by forming soluble complex ions, preventing these minerals from interfering with detergent action, maintaining alkaline pH conditions, and enhancing overall soil detachment from fabric surfaces during washing.

92. (B) Sulfuric acid - Skin moisturizing
Sulfuric acid is a highly corrosive, strong mineral acid that causes severe chemical burns and skin destruction, making its use for skin moisturizing incorrect and hazardous. Correct household applications include muriatic acid for removing mineral scale in toilets, aqueous ammonia for streak-free glass cleaning, and mild acetic acid in vinegar for descaling household appliances.

93. (C) Assertion (A) is true but Reason (R) is false.
Synthetic detergents possessing highly branched alkyl chains cause persistent foaming in lakes and rivers because these complex branched structures are resistant to enzymatic degradation by bacteria in wastewater treatment systems. Therefore, Assertion (A) accurately states the environmental problem, whereas Reason (R) is false because branched chains resist biological breakdown rather than undergoing rapid bacterial decomposition.

94. (C) Phosphates
Eutrophication in natural water bodies is frequently caused by phosphate additives present in municipal washing powders. When laundry effluents carrying excess phosphates enter lakes or rivers, these nutrients stimulate rapid, uncontrolled growth of algae and aquatic plants. The subsequent decomposition of dense algal blooms by aerobic bacteria depletes dissolved oxygen, threatening aquatic animal life.

95. (D) They maintain alkalinity and soften water to enhance cleaning.
Chemical builders added to commercial washing powders serve primary roles in softening hard water and maintaining optimal alkaline pH during the wash cycle. Builders bind dissolved calcium and magnesium ions, prevent soil redeposition onto washed fabrics, and saponify acidic grease soils, creating optimal chemical conditions for primary surfactant molecules to remove dirt efficiently.

96. (C) They degrade rapidly without accumulating or foaming in water.
Encouraging the widespread use of eco-friendly detergents is essential because these formulations contain linear hydrocarbon chains and phosphate-free builders that degrade rapidly via natural biological processes. Rapid microbial breakdown prevents chemical accumulation, persistent surface foam formation, and nutrient-driven eutrophication in natural rivers and aquatic ecosystems, protecting marine and freshwater biodiversity.

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97. (B) P-4, Q-3, R-2, S-1
Nylon-6 is synthesized by the ring-opening polymerisation of caprolactam. Polyacrylonitrile, commonly called Orlon, is formed from acrylonitrile monomers. Polystyrene is prepared by polymerizing styrene. Polypropene is synthesized via the addition polymerisation of propene gas. Matching each synthetic polymer to its specific starting monomer unit illustrates fundamental chemical synthesis relationships across industrial polymer manufacturing pathways.

98. (D) Polytetrafluoroethylene
Polytetrafluoroethylene, commonly known by the brand name Teflon, is the synthetic fluoropolymer used as a non-stick coating on cookware. Composed of repeating tetrafluoroethene monomer units, PTFE contains strong carbon-fluorine covalent bonds that confer extreme chemical inertness, high thermal stability, water

repellency, and an exceptionally low coefficient of friction, preventing food from sticking.

99. (A) Elastomers → Plastics → Fibres
Polymers are classified by increasing strength of intermolecular forces in the order: elastomers, plastics, and fibers. Elastomers possess weak intermolecular van der Waals forces that allow high elasticity and stretchability. Plastics exhibit intermediate attractive forces, enabling thermal molding. Fibres possess the strongest intermolecular forces, such as hydrogen bonding, providing high tensile strength and minimal elasticity.

100. (C) Acrylonitrile
Orlon, an acrylic fiber used as a lightweight synthetic substitute for natural wool in sweaters and blankets, is formed by the addition polymerisation of acrylonitrile monomers. The presence of polar nitrile side groups produces strong dipole-dipole intermolecular attractions along polyacrylonitrile polymer chains, imparting high tensile strength, thermal warmth, shape retention, and resistance to chemical weathering.

101. (A) Teflon
Teflon, or polytetrafluoroethylene, exhibits high resistance to heat, chemical attack, and mechanical friction due to its carbon-fluorine bonds. These non-reactive chemical properties and thermal endurance make Teflon an ideal material for manufacturing industrial chemical gaskets, corrosion-resistant valve packings, electrical insulation jacketing, and durable non-stick coatings on commercial culinary cookware surfaces.

102. (D) I and IV only
Vulcanised rubber possesses significantly higher tensile strength, mechanical toughness, and resistance to chemical oxidation compared to unvulcanised natural rubber. Sulfur cross-links introduced during vulcanisation form a network structure that reduces water absorption, eliminates thermal stickiness, and prevents plastic deformation under load, making vulcanised rubber far superior for high-performance automotive tires and industrial belts.

103. (B) Milligrams of KOH required to saponify one gram of fat.
The saponification value of a fat or oil is defined as the number of milligrams of potassium hydroxide required to completely hydrolyze and saponify one gram of that specific fat sample. This analytical value is inversely proportional to the average molecular mass of fatty acids present in the triglyceride sample, serving as a key quality metric.

104. (C) P-4, Q-3, R-1, S-2
Shaving soaps incorporate rosin and glycerol to produce persistent, creamy lather. Transparent soaps are produced by dissolving soap in ethanol and evaporating excess solvent. Medicated soaps contain antiseptic agents like neem or chloroxylenol to combat skin pathogens. Floating soaps are aerated with microscopic bubbles prior to hardening to lower overall density below water.

105. (C) Both Statement I and Statement II
Nylon-2-nylon-6 is a polyamide copolymer synthesized from glycine and aminocaproic acid that contains functional linkages susceptible to natural enzymatic cleavage, making it an environmentally friendly biodegradable polymer. In contrast, conventional Nylon-6,6 synthesized from adipic acid and hexamethylenediamine possesses a stable structure that resists microbial degradation, persisting in natural environments after disposal.

106. (A) Melamine resin
Melamine resin is a classic example of a thermosetting polymer formed by the condensation reaction of melamine with formaldehyde. Thermal molding induces irreversible chemical cross-linking between polymer chains, forming a rigid three-dimensional network. Once set, melamine resin cannot be remelted or reshaped by heating, providing high heat resistance suitable for unbreakable dinnerware and flame-retardant laminates.

107. (B) Rosin
Rosin, a natural resin derived from pine trees, is added during the manufacture of shaving soaps to form sodium rosinate upon reaction with alkali. Sodium rosinate produces rich, voluminous, and long-lasting lather that prevents shaving foam from drying rapidly on human skin, facilitating smooth razor movement and enhancing facial hair removal during shaving.

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108. (B) Glycerol
Glycerol, a trihydroxy alcohol derivative, is commonly added to premium bathing soaps to act as a humectant and skin moisturizer. Glycerol attracts moisture from the surrounding environment to skin surfaces, preventing post-washing dryness and irritation. Its hydrating properties maintain skin elasticity and softness while helping preserve the physical moisture content of soap bars during usage.

109. (A) II, IV, I, III
The standardized plastic resin identification coding system assigns numeric codes inside chasing arrow triangles to facilitate recycling sorting. Polyethylene terephthalate is designated as Code 1, high-density polythene as Code 2, polyvinyl chloride as Code 3, and low-density polythene as Code 4. Arranging these polymers in order from Code 1 to 4 yields PET, HDPE, PVC, and LDPE.

110. (C) Unbreakable crockery
Melamine polymer resin is widely used in the commercial manufacture of unbreakable crockery, dinner plates, bowls, and serving trays. As a thermosetting cross-linked polymer, melamine possesses high physical hardness, flame resistance, surface durability, and heat tolerance. These properties prevent cracking, warping, and staining under typical domestic dishwashing temperatures, making it superior to conventional ceramic tableware.

111. (D) cis-1,4-polyisoprene
Natural rubber is chemically defined as cis-1,4-polyisoprene, formed by the natural addition polymerisation of isoprene monomers. In this cis stereochemical configuration, identical double-bond substituent groups reside on the same side of the polyisoprene chain, preventing close structural packing and producing weak intermolecular forces that account for natural rubber's characteristic flexibility and elasticity.

112. (C) Ziegler-Natta catalyst
High-density polythene is synthesized at low pressure and temperature using a Ziegler-Natta catalyst, typically comprising triethylaluminum and titanium tetrachloride. This coordination catalyst coordinates ethene monomers into linear, unbranched polymer chains that pack closely together, creating high density, superior tensile strength, elevated melting points, and high rigidity compared to branched low-density polythene variants.

113. (B) Semi-synthetic polymer
Rayon, commonly called artificial silk, is classified as a semi-synthetic polymer because it is manufactured by chemically treating naturally occurring cellulose obtained from wood pulp. Naturally derived cellulose is dissolved in chemical solvents and regenerated as continuous lustrous filaments. Because it involves chemical modification of a natural polymer substrate, rayon bridges natural biopolymers and fully synthetic materials.

114. (D) P-3, Q-1, R-4, S-2
Polycarbonate is used for shatterproof safety glasses and optical CDs due to high impact strength. Kevlar possesses exceptional tensile strength, making it ideal for bulletproof vests. Polystyrene is expanded into foam packaging and thermocol cups. Polyurethane is processed into flexible foams for mattresses and seat cushions. Matching these synthetic polymers to their functional applications highlights industrial utility.

115. (A) Cetyltrimethylammonium bromide
Cetyltrimethylammonium bromide is a cationic detergent featuring a quaternary ammonium cation with a long hydrophobic hydrocarbon chain attached to a positively charged nitrogen atom. Because of its cationic surfactant character and antibacterial germicidal properties, cetyltrimethylammonium bromide is used in commercial hair conditioners, hair rinses, and specialized medical antiseptics to neutralize static charge and soften hair.

116. (C) Sodium lauryl sulfate
Sodium lauryl sulfate is an anionic detergent widely utilized in household laundry powders, shampoos, and toothpaste. Its chemical structure features a long non-polar alkyl chain attached to a negatively charged sulfate polar head group paired with a sodium counter-ion. This anionic nature confers high water solubility, strong foaming capability, and effective soil emulsification during cleaning.

117. (A) Liquid dishwashing detergents
Non-ionic detergents possess no ionic charges in their molecular structure, containing neutral polar groups like polyoxyethylene chains

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attached to lipophilic alkyl tails. Because non-ionic surfactants do not ionize in water, they exhibit low foaming tendencies, high grease emulsification power, and resistance to hard water minerals, making them ideal ingredients for liquid dishwashing formulations.

118. (D) Soaps increase the surface tension of water, allowing it to act like a sharp knife to cut dirt.
The statement that soaps increase surface tension to act like a sharp knife is incorrect. In reality, soaps and detergents lower the surface tension of water by disrupting cohesive hydrogen bonding among water molecules at the surface. Lowering surface tension allows water to spread, wet fabric surfaces effectively, penetrate microscopic pores, and remove soil particles.

119. (B) Nylon-2-nylon-6
Nylon-2-nylon-6 is an environmentally friendly, biodegradable polyamide copolymer synthesized from glycine and aminocaproic acid. Unlike synthetic non-biodegradable polymers like Nylon-6,6, Polyvinyl Chloride, and Polystyrene, Nylon-2-nylon-6 contains alternating amide functional groups accessible to enzymatic cleavage by soil microorganisms, breaking down naturally without leaving persistent ecological waste in natural terrestrial environments.

120. (C) Colloid
During the cleansing action of soap, formed micelles remain uniformly suspended throughout the aqueous medium without settling or precipitating because they constitute a stable colloidal dispersion. Negative electrostatic charges present on the outer hydrophilic carboxylate heads of adjacent micelles exert mutual electrostatic repulsion, preventing micellar agglomeration and maintaining stable suspended oil-in-water colloidal emulsions throughout the wash.

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CHAPTER 06

Reflection and Dispersion of Light

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1. What is the nature of light according to the modern quantum theory?
(A) Only wave nature
(B) Both wave and particle nature
(C) Only particle nature
(D) Neither wave nor particle nature

2. According to the laws of reflection of light, which of the following statements is correct?
(A) The angle of incidence is always greater than the angle of reflection.
(B) The angle of incidence is always equal to the angle of reflection.
(C) The angle of incidence is always less than the angle of reflection.
(D) The angle of reflection depends on the refractive index of the medium.

3. What is the nature of the image formed by a plane mirror?
(A) Virtual, erect, and of the same size as the object
(B) Real, inverted, and of the same size as the object
(C) Virtual, erect, and magnified
(D) Real, erect, and diminished

4. What is the speed of light in a vacuum?
(A) 3×10^5 m/s
(B) 3×10^8 m/s
(C) 3×10^{10} m/s
(D) 3×10^8 km/s

5. The bouncing back of light rays into the same medium after striking a smooth surface is called:
(A) Reflection of light
(B) Refraction of light
(C) Dispersion of light
(D) Scattering of light

6. The ratio of the speed of light in a vacuum to the speed of light in a given medium is known as:
(A) Optical density
(B) Relative refractive index
(C) Transmissivity
(D) Absolute refractive index

7. The focal length of a spherical mirror is equal to:
(A) Its radius of curvature
(B) Half of its radius of curvature
(C) Twice its radius of curvature
(D) One-fourth of its radius of curvature

8. Which of the following mirrors provides the widest field of view?
(A) Plane mirror
(B) Concave mirror
(C) Convex mirror
(D) Cylindrical mirror

9. The blue colour of the sky is primarily due to which phenomenon of light?
(A) Total internal reflection
(B) Dispersion of light
(C) Interference of light
(D) Scattering of light

10. Match List I with List II and select the correct answer using the options given below.
List I: (Phenomenon)
P. Twinkling of stars
Q. Blue colour of the sky
R. Mirage in a desert
S. Splitting of white light into seven colours
List II: (Cause of Phenomenon)
1. Scattering of light
2. Dispersion of light
3. Total internal reflection
4. Atmospheric refraction
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

11. Which of the following correctly represents the mirror formula?
(A) $1/v - 1/u = 1/f$
(B) $1/v + 1/u = 1/f$
(C) $v + u = f$
(D) $1/v + 1/f = 1/u$

12. What is the linear magnification produced by a plane mirror?
(A) Less than 1

(B) Greater than 1
(C) Exactly +1
(D) Exactly -1

13. The phenomenon of splitting of white light into its constituent colours upon passing through a transparent medium like a prism is called:
(A) Dispersion
(B) Refraction
(C) Reflection
(D) Scattering

14. When white light passes through a glass prism, which colour bends the least?
(A) Violet
(B) Blue
(C) Red
(D) Yellow

15. Consider the following statements regarding spherical mirrors:
I. The focal length of a concave mirror is taken as negative according to the new Cartesian sign convention.
II. A convex mirror always forms a virtual, erect, and diminished image.
III. The centre of curvature of a convex mirror lies in front of its reflecting surface.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

16. The fundamental cause of refraction of light when it passes from one medium to another is:
(A) The change in the frequency of light
(B) The change in the intensity of light
(C) The change in the speed of light
(D) The scattering of light by particles

17. The sun is visible to us about 2 minutes before the actual sunrise and about 2 minutes after the actual sunset because of:
(A) Scattering of light
(B) Atmospheric refraction
(C) Total internal reflection
(D) Dispersion of light

18. Arrange the following mediums in increasing order of their absolute refractive index:
1. Diamond
2. Air
3. Water
4. Crown Glass

Select the correct code:
(A) 2, 3, 4, 1
(B) 2, 4, 3, 1
(C) 1, 4, 3, 2
(D) 3, 2, 4, 1

19. The scattering of a beam of light by colloidal particles, making the path of light visible, is known as:
(A) Tyndall effect
(B) Raman effect
(C) Doppler effect
(D) Zeeman effect

20. Optical fibres, used extensively in modern telecommunications, work on the principle of:
(A) Refraction of light
(B) Dispersion of light
(C) Total internal reflection
(D) Scattering of light

21. The optical illusion observed in deserts during hot summer days, where water appears to be present on the ground, is known as:
(A) Mirage
(B) Looming
(C) Tyndall effect
(D) Halo

22. What does the acronym LASER stand for?
(A) Light Absorption by Spontaneous Emission of Radiation
(B) Light Alteration by Stimulated Energy Radiation
(C) Light Amplification by Systematic Emission of Rays
(D) Light Amplification by Stimulated Emission of Radiation

23. Where is the image formed when an object is placed at the centre of curvature (C) of a concave mirror?
(A) At the focus (F)
(B) At the centre of curvature (C)
(C) Between the focus (F) and the centre of curvature (C)
(D) Beyond the centre of curvature (C)

24. Which type of mirror is most commonly used as a rear-view mirror in vehicles?
(A) Plane mirror
(B) Concave mirror
(C) Convex mirror
(D) Parabolic mirror

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25. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Stars appear to twinkle in the night sky, but planets do not.
Reason (R): Stars are much farther away from Earth and approximate point-sized sources of light, while planets are closer and act as extended sources.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

26. In the visible spectrum of light formed by a glass prism, which colour undergoes maximum deviation?
(A) Violet
(B) Red
(C) Green
(D) Yellow

27. The formation of a rainbow involves which of the following optical phenomena?
(A) Only dispersion and scattering
(B) Refraction, dispersion, and total internal reflection
(C) Only refraction and reflection
(D) Refraction, scattering, and interference

28. Which mirror is used by dentists to see enlarged images of a patient's teeth?
(A) Convex mirror
(B) Concave mirror
(C) Plane mirror
(D) Bifocal mirror

29. The speed of light in a medium is inversely proportional to:
(A) The absolute refractive index of the medium
(B) The thermal temperature of the medium
(C) The optical wavelength of the light
(D) The wave frequency of the light

30. The discrete packets or quanta of light energy are known as:
(A) Protons
(B) Electrons
(C) Photons
(D) Neutrinos

31. According to Snell's law of refraction, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is:
(A) Variable for any given pair of transparent media and light
(B) Equal to zero for any given pair of optical media and light
(C) Always equal to 1 for any pair of media and colour of light
(D) Constant for a given pair of media and given colour of light

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32. Match List I with List II and select the correct answer using the options given below.
List I: (Mirror Type)
P. Concave mirror
Q. Convex mirror
R. Plane mirror
S. Parabolic mirror
List II: (Application)
1. Solar furnaces
2. Rear-view mirrors in cars
3. Looking glass (dressing table)
4. Headlights of vehicles
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-3, R-2, S-4
(D) P-2, Q-1, R-4, S-3

33. Danger signals are universally made red in colour because red light:
(A) Is scattered the most by atmospheric particles
(B) Is scattered the least by atmospheric particles
(C) Has the shortest wavelength
(D) Has the highest frequency

34. A person using a concave mirror for shaving should place his face:
(A) At the principal focus
(B) At the centre of curvature
(C) Beyond the centre of curvature
(D) Between the pole and the principal focus

35. The magnification (m) produced by a spherical mirror can be expressed as the ratio of image height (h') to object height (h). In terms of object distance (u) and image distance (v), it is:
(A) $m = -(v / u)$
(B) $m = v / u$

(C) m = u / v
(D) m = - (u / v)

36. If light travels from air to glass, its speed:
(A) Increases
(B) Decreases
(C) Remains the same
(D) First increases then decreases

37. Who was the first scientist to use a glass prism to obtain the spectrum of sunlight?
(A) Isaac Newton
(B) Albert Einstein
(C) Thomas Young
(D) Max Planck

38. Which of the following represents the correct sequence of colours in the visible spectrum (VIBGYOR) in decreasing order of their wavelength?
(A) Red, Orange, Yellow, Green, Blue, Indigo, Violet
(B) Violet, Indigo, Blue, Green, Yellow, Orange, Red
(C) Red, Yellow, Orange, Green, Indigo, Blue, Violet
(D) Violet, Blue, Indigo, Green, Orange, Yellow, Red

39. Due to atmospheric refraction, the apparent position of a star is:
(A) Exactly the same as its actual position
(B) Slightly lower than its actual position
(C) Slightly higher than its actual position
(D) Independent of the earth's atmosphere

40. The reflection of light from a rough, uneven surface like a wall or a piece of paper is known as:
(A) Regular reflection
(B) Specular reflection
(C) Diffuse reflection
(D) Total internal reflection

41. When sunlight passes through the canopy of a dense forest, the path of light becomes visible. This is a real-life example of:
(A) Atmospheric refraction
(B) Dispersion
(C) Mirage
(D) Tyndall effect

42. Consider the following statements about convex mirrors:
I. They always form diminished images.
II. They are commonly used as reflectors in street lamps to diverge light over a larger area.
III. They can form real images if the object is kept very close to the pole.
Which of the above statement(s) is/are incorrect?
(A) I and II
(B) Only III
(C) II and III
(D) I, II and III

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43. Total internal reflection occurs only when a ray of light travels from:
(A) An optically rarer medium to a denser medium
(B) An optically denser medium to a rarer medium
(C) A transparent medium to an opaque medium
(D) Air to water

44. If an object is moving towards a plane mirror at a speed of 2 m/s, at what speed does the image appear to approach the object?
(A) 1 m/s
(B) 2 m/s
(C) 4 m/s
(D) 8 m/s

45. A ray of light passing obliquely from an optically rarer medium to an optically denser medium:
(A) Bends towards the normal
(B) Bends away from the normal
(C) Goes undeviated
(D) Reflects back along the same path

46. The scientific study of the interaction between matter and electromagnetic radiation as a function of wavelength is known as:
(A) Microscopy
(B) Telescopy
(C) Spectroscopy
(D) Optometry

47. An image formed by a concave mirror is observed to be virtual, erect, and larger than the object. Where should the position of the object be?
(A) Between the principal focus and the centre of curvature
(B) At the centre of curvature
(C) Beyond the centre of curvature
(D) Between the pole of the mirror and its principal focus

48. Match List I with List II and select the correct answer using the options given below.

List I: (Medium)
P. Vacuum
Q. Water
R. Crown glass
S. Diamond
List II: (Approximate Refractive Index)
1. 1.00
2. 1.33
3. 1.52
4. 2.42
(A) P-1, Q-2, R-3, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-4, Q-2, R-3, S-1
(D) P-2, Q-1, R-4, S-3

49. A rainbow is typically observed in the sky:
(A) Before a rain shower, facing towards the sun
(B) After a rain shower, facing away from the sun
(C) After a rain shower, facing towards the sun
(D) During a rain shower, facing towards the sun

50. The difference in the refractive index of glass for different colours of light is the primary cause of:
(A) Reflection
(B) Interference
(C) Diffraction
(D) Dispersion

51. If the angle between the incident ray and the plane mirror is 30 degrees, what will be the angle of reflection?
(A) 30 degrees
(B) 60 degrees
(C) 90 degrees
(D) 120 degrees

52. The apparent flattening of the sun's disc at sunrise and sunset is a phenomenon caused by:
(A) Dispersion of light
(B) Total internal reflection
(C) Atmospheric refraction
(D) Scattering of light

53. The brilliant sparkle of a cut diamond is mainly due to:
(A) Total internal reflection
(B) Its high transparency
(C) Dispersion of light inside it
(D) Its extreme hardness

54. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?
(A) 40 cm
(B) 20 cm
(C) 10 cm
(D) 5 cm

55. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The sun appears reddish during sunrise and sunset.
Reason (R): During sunrise and sunset, the light has to travel a shorter distance through the earth's atmosphere, leading to maximum scattering of red light.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

56. Which of the following equations correctly relates the speed of light (c), frequency (f), and wavelength (λ)?
(A) $c = f / \lambda$
(B) $c = \lambda / f$
(C) $c = f \times \lambda$
(D) $f = c \times \lambda$

57. Which characteristic of light remains unchanged when it passes from one medium to another?
(A) Velocity
(B) Wavelength
(C) Amplitude
(D) Frequency

58. For an object placed at infinity, a concave mirror forms an image at:
(A) The principal focus
(B) The pole
(C) The centre of curvature
(D) Infinity

59. The refractive index of a medium is strictly defined with respect to:
(A) Air
(B) Vacuum
(C) Water
(D) Glass

60. The sequence of colours in a secondary rainbow is:
(A) Identical to the primary rainbow

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(B) Reversed from the primary rainbow
(C) Random compared to the primary rainbow
(D) Incomplete compared to the primary rainbow

61. A glass prism has two triangular bases and how many rectangular lateral surfaces?
(A) Two
(B) Three
(C) Four
(D) Five

62. The critical angle for a medium is the angle of incidence in the denser medium for which the angle of refraction in the rarer medium is:
(A) 0 degrees
(B) 45 degrees
(C) 90 degrees
(D) 180 degrees

63. Two plane mirrors are placed parallel to each other. How many images of a coin placed between them will be formed?
(A) 2
(B) 4
(C) 8
(D) Infinite

64. Why do planets not twinkle like stars?
(A) Planets do not emit light of their own.
(B) Planets are much larger in actual physical size than stars.
(C) Planets are closer to Earth, so variations in atmospheric refraction average out.
(D) Planets are located outside the earth's atmosphere.

65. Match List I with List II and select the correct answer using the options given below.
List I: (Colour of Light)
P. Red
Q. Violet
R. Green
S. Yellow
List II: (Wavelength Characteristic in Visible Spectrum)
1. Longest wavelength
2. Shortest wavelength
3. Intermediate wavelength (between blue and yellow)
4. Intermediate wavelength (between green and orange)

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-1, Q-3, R-2, S-4
(D) P-4, Q-2, R-3, S-1

66. When an object is placed between the centre of curvature (C) and the principal focus (F) of a concave mirror, the image formed is:
(A) Real, inverted, and diminished
(B) Virtual, erect, and magnified
(C) Virtual, erect, and diminished
(D) Real, inverted, and magnified

67. The phenomenon of light responsible for the formation of an image in a pinhole camera is:
(A) Rectilinear propagation
(B) Total internal reflection
(C) Dispersion
(D) Scattering

68. Consider the following statements regarding the refractive index:
I. The refractive index of a transparent medium is always greater than 1.
II. A medium with a higher refractive index is optically rarer than a medium with a lower refractive index.
III. The refractive index has no unit.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II, and III

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69. Which unique property of laser light makes it highly useful in precision surgery and bar-code scanning?
(A) It is highly coherent and monochromatic.
(B) It is highly scattered.
(C) It consists of entirely unpolarized light.
(D) It travels faster than ordinary light.

70. When monochromatic light passes through a prism, which phenomenon does NOT occur?
(A) Refraction
(B) Deviation
(C) Change in speed
(D) Dispersion

71. The centre of the reflecting surface of a spherical mirror is a point called the:
(A) Focus
(B) Pole
(C) Centre of curvature
(D) Aperture

72. Which principle states that a light ray travelling from one point to another will take the path that requires the least time?
(A) Huygens' Principle
(B) Heisenberg's Principle
(C) Fermat's Principle
(D) Newton's Principle

73. Arrange the following events in the order they occur to a light ray entering a glass prism:
1. Emergence into air
2. Refraction at the first air-glass boundary
3. Splitting into constituent colours
4. Travel through the body of the prism
Select the correct sequence:
(A) 2, 3, 4, 1
(B) 3, 2, 4, 1
(C) 2, 4, 3, 1
(D) 4, 2, 3, 1

74. According to Rayleigh's law of scattering, the intensity of scattered light is inversely proportional to:
(A) The first power of the wavelength
(B) The second power of the wavelength
(C) The third power of the wavelength
(D) The fourth power of the wavelength

75. The band of seven colours obtained on a screen when white light passes through a prism is called a:
(A) Mirage
(B) Spectrum
(C) Halo
(D) Tyndall band

76. In the formation of a primary rainbow, the sunlight undergoes how many internal reflections inside the water drop?
(A) Zero
(B) One
(C) Two
(D) Three

77. A ray of light normally incident on a glass slab (angle of incidence = 0 degrees) will have an angle of refraction of:
(A) 0 degrees
(B) 45 degrees
(C) 90 degrees
(D) Critical angle

78. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Optical fibres can transmit light signals over long distances without significant loss of energy.
Reason (R): Optical fibres operate on the principle of total internal reflection, trapping the light within the core.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

79. The ratio of the sine of the angle of incidence to the sine of the angle of emergence in a rectangular glass slab is:
(A) Greater than 1
(B) Less than 1
(C) Exactly 1
(D) Dependent on the thickness of the slab

80. If you are standing 2 metres away from a plane mirror, what is the distance between you and your image?
(A) 1 metre
(B) 2 metres
(C) 4 metres
(D) 8 metres

81. In which of the following media does light travel the fastest?
(A) Water
(B) Air
(C) Glass
(D) Diamond

82. Match List I with List II and select the correct answer using the options given below.
List I: (Optical Element)
P. Plane Mirror
Q. Glass Slab
R. Glass Prism
S. Water Droplet (Rainbow)
List II: (Dominant Phenomenon)
1. Lateral displacement
2. Regular reflection
3. Dispersion and total internal reflection
4. Dispersion and angular deviation
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4

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(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

83. An instrument that uses a prism or diffraction grating to separate light into its component wavelengths for analysis is called a:
(A) Spectrometer
(B) Periscope
(C) Microscope
(D) Kaleidoscope

84. A spherical mirror whose reflecting surface is curved outwards is called a:
(A) Concave mirror
(B) Plane mirror
(C) Convex mirror
(D) Parabolic mirror

85. Stars twinkle but the moon does not because:
(A) The moon is much closer to Earth than the stars.
(B) The moon has no atmospheric layer surrounding it.
(C) The moon shines entirely by reflecting sunlight.
(D) Stars produce a continuous spectrum of bright light.

86. Which colour of light scatters the most in the earth's atmosphere?
(A) Red
(B) Yellow
(C) Green
(D) Violet/Blue

87. When light travels from a denser medium to a rarer medium, its speed:
(A) Decreases
(B) Increases
(C) Remains unchanged
(D) Becomes zero

88. For total internal reflection to occur, the angle of incidence must be:
(A) Less than the critical angle
(B) Equal to the critical angle
(C) Greater than the critical angle
(D) Perpendicular to the critical angle

89. Consider the following statements about a rainbow:
I. It is always formed in the direction opposite to that of the sun.
II. Red colour appears on the outer edge of a primary rainbow.
III. Violet colour appears on the inner edge of a primary rainbow.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

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90. Which of the following is NOT an application of the reflection of light?
(A) Optical fibre
(B) Periscope
(C) Kaleidoscope
(D) Shaving mirror

91. To get a real, inverted, and same-sized image from a concave mirror, the object should be placed:
(A) At the focus
(B) At the centre of curvature
(C) Between the pole and focus
(D) Beyond the centre of curvature

92. The speed of light in water (refractive index = 1.33) is approximately:
(A) 2.25×10^8 m/s
(B) 3.00×10^8 m/s
(C) 1.50×10^8 m/s
(D) 2.00×10^8 m/s

93. A glass prism separates white light into a spectrum. Which property of the glass varies for different colours causing this effect?
(A) Refractive index
(B) Mass density
(C) Hardness
(D) Temperature

94. Astronauts in space see the sky as black because:
(A) Outer space is extremely cold and completely dark.
(B) The sun does not emit visible light rays into space.
(C) There is no atmosphere in space to scatter sunlight.
(D) Human eyes cannot adjust to the high vacuum of space.

95. Match List I with List II and select the correct answer using the options given below.
List I: (Sign Convention)
P. Object distance (u)
Q. Focal length (f)
R. Image distance (v) for a real image
S. Height of a real image (h')

List II: (Parameter for Concave Mirror)
1. Always negative
2. Negative
3. Negative
4. Negative

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-1, Q-2, R-4, S-3
(D) P-1, Q-2, R-3, S-4

96. If the refractive index of glass with respect to air is 3/2, what is the refractive index of air with respect to glass?
(A) 3/2
(B) 2/3
(C) 1/2
(D) 3

97. In laser technology, 'Stimulated Emission' means that an incoming photon forces an excited atom to emit a second photon that is:
(A) Completely random in direction
(B) Identical in phase, frequency, and direction
(C) Of a higher energy than the incoming photon
(D) Always in the ultraviolet spectrum

98. Select the correct sequence of phenomena responsible for the reddish appearance of the sun at sunrise.
(A) White light enters atmosphere → Shorter wavelengths scatter away → Red light reaches the observer
(B) White light enters atmosphere → Red light scatters the most → Red light reaches the observer
(C) White light enters atmosphere → Total internal reflection occurs → Red light reaches the observer
(D) White light enters atmosphere → Dispersion creates a spectrum → Red light is magnified

99. Endoscopy, a medical procedure used to look inside the body, relies primarily on which principle?
(A) Total internal reflection
(B) X-ray diffraction
(C) Dispersion of light in tissue
(D) Reflection from plane mirrors

100. A concave mirror produces a magnification of +2. This indicates that the image is:
(A) Real, inverted, and magnified
(B) Real, erect, and diminished
(C) Virtual, erect, and magnified
(D) Virtual, inverted, and diminished

101. The effective diameter of the circular outline of a spherical mirror is called its:
(A) Aperture
(B) Principal axis
(C) Radius of curvature
(D) Focal plane

102. When light rays travel from water into air, the refracted rays bend:
(A) Towards the normal
(B) Away from the normal
(C) Parallel to the normal
(D) Perpendicular to the surface

103. At noon, the sun appears white because:
(A) All colours are scattered equally across the atmosphere.
(B) Light travels a shorter distance, so scattering is minimal.
(C) Total internal reflection absorbs blue light from the sun.
(D) Refraction increases the intensity of all colours equally.

104. Which mirror would be best suited for use as a reflector in a solar cooker to converge sunlight at a point?
(A) Plane mirror
(B) Convex mirror
(C) Concave mirror
(D) Spherical diverging mirror

105. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Diamonds sparkle brilliantly when cut properly.
Reason (R): The critical angle for diamond is very small, causing incident light to undergo multiple total internal reflections.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

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106. A convex mirror has a focal length of 15 cm. If an object is placed at a distance of 10 cm from the mirror, the image formed will be:
(A) Virtual and erect
(B) Real and erect
(C) Real and inverted
(D) Virtual and inverted

107. The straight line passing through the pole and the centre of curvature of a spherical mirror is called the:
(A) Focal length
(B) Principal axis
(C) Secant line
(D) Aperture chord

108. The acronym VIBGYOR is used to remember the colours of the spectrum. What does 'I' stand for?
(A) Intense
(B) Indigo
(C) Infrared
(D) Isotropic

109. Match List I with List II and select the correct answer using the options given below.
List I: (Application)
P. Barcode scanner
Q. Checking fake currency
R. Telecommunication cables
S. Viewing microscopic structures
List II: (Type of Light/Phenomenon)
1. Ultraviolet light
2. Laser light
3. Refraction
4. Total internal reflection
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

110. The laws of reflection hold true for:
(A) Only smooth plane reflecting surfaces
(B) Only curved concave mirror surfaces
(C) All reflecting surfaces regardless of shape
(D) Only curved convex mirror surfaces

111. Which atmospheric condition is essential for the observation of a rainbow?
(A) Heavy snowfall occurring in the upper atmosphere
(B) Extremely dry, hot air with high temperature
(C) Total cloud cover completely blocking the sun
(D) Presence of water droplets acting as tiny prisms

112. Consider the following statements regarding the Tyndall effect:
I. It is caused by the scattering of light by colloidal particles.
II. It can be observed when a fine beam of sunlight enters a smoke-filled room.
III. It explains why the sky appears black to an astronaut.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

113. If the earth had no atmosphere, the sky during the day would appear:
(A) Blue
(B) Dark / Black
(C) Red
(D) White

114. Refractive index depends on which of the following properties?
(A) Density of the medium
(B) Angle of incidence
(C) Shape of the medium
(D) Nature of the medium

115. In a mirage, the layers of air near the hot ground behave as an:
(A) Optically rarer medium
(B) Optically denser medium
(C) Opaque medium
(D) Isotropic solid

116. Emission spectroscopy is typically used to determine:
(A) The physical state of a solid material
(B) The speed of light in a transparent medium
(C) The chemical composition of a light source
(D) The gravitational pull of a celestial star

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117. When a light ray is incident normally on a plane mirror, the angle of reflection is:
(A) 90 degrees
(B) 180 degrees
(C) 0 degrees
(D) 45 degrees

118. Match List I with List II and select the correct answer using the options given below.
List I: (Value/Constant)

P. 3×10^8 m/s
Q. 1.33
R. 2.42
S. 0 m/s

List II: (Description)

1. Refractive index of water
2. Refractive index of diamond
3. Speed of light in vacuum
4. Speed of light in a perfectly opaque medium

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-3, R-4, S-1

119. A continuous spectrum is usually produced by:
(A) Low-density gases excited by electricity
(B) Incandescent solids, liquids, or dense gases
(C) Cold gases under extremely low pressure
(D) Monochromatic light emitted by lasers

120. Which of the following phenomena proves that light travels in a straight line?
(A) Dispersion of white light
(B) Refraction of light rays
(C) Formation of dark shadows
(D) Interference of light waves

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ANSWERS

1. (B) Both wave and particle nature
Modern quantum mechanics describes light as possessing a dual nature, combining properties of both waves and particles. Phenomena like interference and diffraction demonstrate wave behaviour, whereas effects such as the photoelectric effect showcase particle characteristics. Light propagates through space as discrete wave-packets or quanta known as photons, unifying both classical concepts into a single comprehensive framework.

2. (B) The angle of incidence is always equal to the angle of reflection.
According to the fundamental laws of reflection, the angle of incidence is always strictly equal to the angle of reflection for any reflecting surface. Additionally, the incident ray, the reflected ray, and the normal to the reflecting surface at the point of incidence all lie simultaneously within the same geometric plane regardless of surface curvature.

3. (A) Virtual, erect, and of the same size as the object
Plane mirrors form virtual images because reflected rays appear to diverge from a point behind the mirror surface. The image is upright or erect, laterally inverted, and situated at a distance behind the mirror identical to the distance of the physical object in front of it. Consequently, the magnification produced remains precisely unity.

4. (B) 3 x 10^8 m/s
The speed of electromagnetic radiation, including visible light, in a vacuum is a fundamental physical constant denoted by the symbol c. It represents the maximum universal speed limit at which all energy, matter, and information can travel. In standard international metric units, this fundamental speed is measured to be approximately three hundred million metres per second.

5. (A) Reflection of light
Reflection occurs when light encounters a boundary between two different media and is redirected back into its original medium. Smooth or polished surfaces produce specular reflection obeying geometric laws, whereas rough surfaces produce diffuse reflection. This optical phenomenon enables human vision by allowing light bouncing off illuminated objects to enter the observer's eye directly.

6. (D) Absolute refractive index
The absolute refractive index of a material medium measures how significantly light slows down relative to its velocity in a vacuum. Defined mathematically as the speed of light in vacuum divided by the phase velocity in that medium, it is a dimensionless optical property. A higher value signifies greater optical density and greater ray bending during refraction.

7. (B) Half of its radius of curvature
For spherical mirrors with small apertures relative to their radii, paraxial rays focus at a single point on the principal axis called the focus. Geometric optics proves that the distance from the pole to this principal focus, termed focal length, is exactly equal to one-half of the distance to the centre of curvature.

8. (C) Convex mirror
Convex mirrors curve outward toward the light source, causing incident parallel light rays to diverge. Because of this outward curvature, they produce diminished, erect virtual images of objects over a remarkably broad angular range. This characteristic allows them to capture a far wider field of view compared to plane or concave mirror surfaces.

9. (D) Scattering of light
Solar radiation travelling through the Earth's atmosphere encounters nitrogen and oxygen molecules much smaller than the wavelength of visible light. According to Rayleigh's law, shorter wavelengths like blue and violet undergo significantly more intense scattering than longer wavelengths such as red. Because human eyes are more sensitive to blue, the clear daytime sky appears predominantly blue.

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10. (A) P-4, Q-1, R-3, S-2
Atmospheric turbulence causes refractive index fluctuations, leading to star twinkling via refraction. Air particle scattering gives the sky its blue hue. Mirages form in hot deserts due to total internal reflection across varying air density layers. Glass prisms separate white light into component colours through chromatic dispersion, establishing the corresponding phenomenon-cause pairs.

11. (B) $1/v + 1/u = 1/f$
The mirror formula describes the quantitative relationship between the object distance, image distance, and focal length for spherical reflecting surfaces. Derived using geometric principles of similar triangles, it states that the sum of the reciprocals of object and image distances equals the reciprocal of focal length, adhering strictly to Cartesian sign conventions.

12. (C) Exactly +1
Linear magnification represents the ratio of image height to object height. A plane mirror forms a virtual image that is upright and identical in dimensions to the physical object. The positive sign denotes an erect image orientation, while a magnitude of one indicates equal sizing, resulting in a constant magnification value of plus one.

13. (A) Dispersion
White light comprises multiple spectral wavelengths, each travelling at different speeds when moving through a dispersive glass prism. Because the refractive index varies inversly with wavelength, individual constituent colours bend by distinct angular amounts at refracting interfaces. This differential refraction separates compound light into its full continuous spectrum, a process termed dispersion.

14. (C) Red
Glass possesses a lower refractive index for longer wavelengths than for shorter ones within the visible spectrum. Red light possesses the longest wavelength in the visible light range, experiencing the smallest velocity reduction upon entering a prism. Consequently, it undergoes the minimum angle of deviation compared to all other constituent spectral colours.

15. (A) I and II only
Under the Cartesian convention, concave mirrors have focus and centre of curvature in front, making focal length negative. Convex mirrors diverge light to produce virtual, erect, diminished images for real objects. However, the centre of curvature of a convex mirror lies behind its reflecting surface rather than in front, validating the first two statements.

16. (C) The change in the speed of light
Refraction is the bending of light rays as they pass obliquely across the boundary separating two optical media of different densities. The primary underlying physical mechanism for this directional shift is the variation in wave propagation speed, which depends directly on optical density, while wave frequency remains strictly constant during transmission.

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17. (B) Atmospheric refraction
The density and refractive index of atmospheric air decrease gradually with increasing altitude. Light rays entering obliquely from space bend progressively toward the normal while travelling through denser lower layers. This continuous bending causes sunlight to reach ground observers even when the physical solar disc remains below the horizon, shifting apparent sunrise and sunset timing.

18. (A) 2, 3, 4, 1
Refractive index indicates the optical density of a medium, where higher values correspond to greater light retardation. Air has an absolute refractive index of approximately 1.0003, water measures about 1.33, crown glass is roughly 1.52, and diamond features a very high value near 2.42, establishing the exact ascending order sequence.

19. (A) Tyndall effect
When a light beam travels through a colloidal suspension, tiny suspended particles scatter individual rays in various directions. This lateral light scattering illuminates the geometric path of the beam, making it clearly visible to observers. Named after physicist John Tyndall, this optical effect distinguishes true solution mixtures from heterogeneous colloidal dispersions.

20. (C) Total internal reflection
Optical fibres consist of a central transparent core coated by a cladding material of lower refractive index. Light signals launched into the core at angles exceeding the critical angle undergo continuous total internal reflection at

the core-cladding boundary. This mechanism guides optical signals across long distances with minimal transmission attenuation or signal degradation.

21. (A) Mirage
Intense solar heating of desert ground creates hot air layers near the surface, decreasing their optical density relative to cooler upper air. Light rays from distant sky or objects bend continuously away from normal as they travel downward, eventually undergoing total internal reflection. Observers perceive inverted images, creating optical illusions of water pools.

22. (D) Light Amplification by Stimulated Emission of Radiation
LASER is an acronym summarizing its quantum mechanical operational mechanism. Electrons in a gain medium are pumped to excited energy states and stimulated by incoming photons to drop to lower levels, releasing identical photons. This process produces coherent, monochromatic, highly directional light waves through Light Amplification by Stimulated Emission of Radiation.

23. (B) At the centre of curvature (C)
When an object is situated precisely at the centre of curvature of a concave mirror, light rays focus such that the resulting image forms at that exact same location. The image produced is real, inverted, and possesses a size identical to the physical object, corresponding to a magnification magnitude of minus one.

24. (C) Convex mirror
Drivers require mirrors that offer broad visual coverage of trailing traffic. Convex mirrors are preferred for vehicle rear-view applications because they consistently generate upright, diminished virtual images regardless of object distance. Their outward curving surface diverges light, significantly enlarging the driver's observable field of view compared to alternative flat or concave optics.

25. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Atmospheric turbulence shifts light paths constantly. Distant stars act as single point sources, so path fluctuations alter their perceived brightness sharply, causing visible twinkling. Nearby planets act as collections of point sources; individual intensity variations average out across their extended disc area, stabilizing their total brightness and preventing the twinkling effect.

26. (A) Violet
In glass, light velocity decreases as wavelength drops. Violet light features the shortest wavelength in the visible spectrum, encountering the highest effective refractive index when passing through a prism. Consequently, its phase speed drops most drastically, forcing violet light rays to bend most sharply and undergo the greatest overall angular deviation.

27. (B) Refraction, dispersion, and total internal reflection
Rainbows form when sunlight interacts with atmospheric raindrops acting as natural prisms. Light refracts upon entering a raindrop, separating into component wavelengths via dispersion. Internal reflection redirects these separated light rays back through the droplet, followed by a second refraction as rays exit, creating a colourful circular arc in the sky.

28. (B) Concave mirror
Concave mirrors converge incident light rays toward a focal point. When an object is positioned inside its focal distance, specifically between the pole and focus, the mirror generates a virtual, erect, and significantly magnified image. Dentists utilize this optical setup to examine detailed, enlarged views of a patient's teeth and gums clearly.

29. (A) The absolute refractive index of the medium
The phase velocity of light within any material medium equals the ratio of vacuum light speed to the absolute refractive index of that medium. Because vacuum light speed is constant, phase velocity varies inversely with refractive index. Consequently, media with higher refractive indices retard light propagation speed more substantially than media with lower values.

30. (C) Photons
Quantum theory dictates that electromagnetic radiation propagates and exchanges energy in discrete indivisible packets called photons or quanta. Each individual photon carries an energy proportional to the frequency of radiation, calculated using Planck's constant. This particle nature of light successfully explains phenomena

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like the photoelectric effect and Compton scattering in physics.

31. (D) Constant for a given pair of media and given colour of light
Snell's law governs optical refraction across medium boundaries. It establishes that for monochromatic light, the ratio of the sine of incidence angle to sine of refraction angle remains constant. This numerical constant equals the relative refractive index between those media, depending solely on light wavelength and optical characteristics of the media.

32. (A) P-1, Q-2, R-3, S-4
Concave mirrors converge parallel sunlight at their focus, serving effectively in solar furnaces. Convex mirrors give wide-angle erect views suitable for automobile rear-view applications. Flat plane mirrors provide undistorted direct viewing as dressing table glasses. Parabolic mirrors focus light into intense parallel beams, eliminating spherical aberration in modern vehicle headlights.

33. (B) Is scattered the least by atmospheric particles
Rayleigh scattering intensity varies inversely with the fourth power of wavelength. Red light possesses the longest wavelength within the visible spectrum, making it scatter least when interacting with atmospheric dust and tiny air particles. Consequently, red signals maintain high intensity over greater distances, penetrating fog or rain to remain clearly visible.

34. (D) Between the pole and the principal focus
A concave mirror produces a virtual, upright, and magnified image when an object is positioned closer than its focal distance, specifically between the pole and the principal focus. Placement at any position farther than the focus yields inverted images. Therefore, placing one's face inside the focal length ensures enlarged shaving views.

35. (A) $m = - (v / u)$
Magnification in spherical mirrors measures image sizing relative to object sizing. By geometric analysis of light rays passing through the pole, magnification is defined as image height divided by object height. Incorporating Cartesian sign conventions, where real images have negative image distances and erect virtual images positive ones, yields minus v over u.

36. (B) Decreases
Glass possesses a higher optical density and absolute refractive index than air. When a ray of light transitions from an optically rarer medium like air into an optically denser medium like glass, its phase propagation speed decreases significantly. The light wave frequency remains unchanged, resulting in a proportional reduction in wavelength.

37. (A) Isaac Newton
Sir Isaac Newton conducted landmark optical experiments in 1665 using a triangular glass prism. He demonstrated that sunlight consists of a combination of distinct spectral colours, which separate upon refraction due to differing dispersion angles. Recombining the spectrum with an inverted second prism proved dispersion was an intrinsic property of light.

38. (A) Red, Orange, Yellow, Green, Blue, Indigo, Violet
In the visible light spectrum, photon energy and wave frequency increase steadily from red to violet, while wavelength decreases correspondingly. Red light exhibits the longest wavelength at roughly seven hundred nanometres, followed by orange, yellow, green, blue, indigo, and finally violet, which possesses the shortest wavelength near four hundred nanometres.

39. (C) Slightly higher than its actual position
Starlight enters Earth's atmosphere from space and travels through layers of progressively increasing air density and refractive index. This gradual change causes the light rays to continuously bend toward the normal. When observers project these incoming rays back along straight lines, the apparent position of the star shifts slightly above its true physical location.

40. (C) Diffuse reflection
Reflection from irregular or unpolished surfaces causes parallel incident light rays to strike surface micro-facets at varying angles of incidence. Consequently, the reflected rays scatter in diverse, non-parallel directions according to local normals. This phenomenon, known as diffuse reflection, allows non-luminous rough objects like paper and walls to be viewed from any orientation.

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41. (D) Tyndall effect
In a dense forest, mist and tiny suspended dust particles function as colloidal droplets suspended in air. When sunlight passes through small gaps in the overhead canopy, these suspended micro-particles scatter visible light laterally along the path. This selective light scattering illuminates the geometric trajectory of the sunbeams, demonstrating the Tyndall effect.

42. (B) Only III
Convex mirrors diverge incoming light rays, always producing virtual, upright, and diminished images for real objects regardless of distance. They scatter rays across broad angles, making them effective street lamp reflectors. However, convex mirrors can never form real images of real objects under any circumstances, making the third statement completely incorrect.

43. (B) An optically denser medium to a rarer medium
Total internal reflection occurs when light attempts to cross from a high refractive index medium into a lower refractive index medium. In this orientation, refracted rays bend away from the normal. If the incident angle exceeds the critical angle, refraction becomes impossible, trapping and reflecting the light entirely within the denser medium.

44. (C) 4 m/s
In a plane mirror, the virtual image forms behind the mirror at a distance equal to the object's distance in front. When an object moves toward the mirror at velocity v, its image also approaches the mirror surface from behind at velocity v. Consequently, the relative approach speed between object and image doubles to 2v.

45. (A) Bends towards the normal
Optically denser media possess higher refractive indices and lower light propagation speeds compared to rarer media. When light enters an optically denser medium obliquely, its wave fronts slow down upon crossing the interface. In accordance with Snell's law, this deceleration forces the light ray to refract at a smaller angle, bending toward normal.

46. (C) Spectroscopy
Spectroscopy is the scientific branch dealing with the thorough investigation and quantitative analysis of how electromagnetic radiation interacts with matter across different wavelengths or frequencies. By measuring absorbed, emitted, or scattered light spectra, researchers determine atomic transitions, energy levels, and detailed chemical compositions of various elements and material compounds.

47. (D) Between the pole of the mirror and its principal focus
Concave mirrors generally form real, inverted images for object positions located at or beyond the focal point. However, when an object is placed inside the principal focus, between the pole and focus, incident rays diverge after reflection. Their backwards extensions meet behind the mirror, creating a virtual, upright, and enlarged image.

48. (A) P-1, Q-2, R-3, S-4
Vacuum serves as the reference medium with a refractive index of exactly 1.00. Water has an optical density yielding a refractive index of approximately 1.33. Crown glass exhibits a higher refractive index near 1.52 due to greater optical retardation. Diamond possesses an exceptionally high refractive index of 2.42, matching the listed values.

49. (B) After a rain shower, facing away from the sun
Rainbow formation requires water droplets in front of the observer and direct sunlight shining from behind. Raindrops refract, disperse, and reflect sunlight back toward the viewer at characteristic angles. Consequently, an observer looking away from the sun after rain sees the spectral arc formed against the sky opposite the light source.

50. (D) Dispersion
Glass is a dispersive optical medium whose refractive index varies as a function of light wavelength. Shorter wavelengths experience higher refractive indices and travel slower through glass than longer wavelengths. When white light enters a glass prism, this wavelength-dependent variation in refractive index causes distinct colors to deviate by different angles, creating dispersion.

51. (B) 60 degrees
Angles in geometric optics are measured relative to the normal line perpendicular to the mirror surface. If the angle between incident ray and mirror surface is thirty degrees, the angle of

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incidence equals ninety minus thirty, or sixty degrees. By the law of reflection, the angle of reflection strictly equals sixty degrees.

52. (C) Atmospheric refraction
During sunrise and sunset, sunlight travels through thick atmospheric layers with varying air densities. Light rays from top and bottom edges of the solar disc undergo differential atmospheric refraction because lower paths bend more strongly than upper paths. This non-uniform refraction lifts the lower edge proportionally more, distorting the sun's circular appearance into flattened oval.

53. (A) Total internal reflection
Diamond possesses an exceptionally high refractive index of 2.42, which produces a very small critical angle of approximately twenty-four degrees. When diamonds are cut with precise geometric facets, light entering through the top undergoes multiple total internal reflections inside the crystal structure before exiting, generating intense spectral brilliancy and sparkle.

54. (C) 10 cm
The focal length of a spherical mirror equals half of its radius of curvature, represented by the mathematical relationship f equals R divided by two. Substituting a radius of curvature of twenty centimetres into this formula yields a focal length of ten centimetres, preserving the direct geometric proportionality inherent in spherical optics.

55. (C) Assertion (A) is true but Reason (R) is false.
At sunrise and sunset, sunlight travels through a longer path of Earth's atmosphere, causing short blue wavelengths to scatter away and leaving predominantly red light. The assertion correctly identifies this reddish appearance, but the reason falsely claims the atmospheric path length is shorter. Consequently, the assertion is true while the reason is false.

56. (C) $c = f \times \lambda$
The wave equation establishes the fundamental relationship governing electromagnetic radiation in a vacuum. Wave speed equals the distance travelled per unit time, which corresponds mathematically to frequency multiplied by wavelength. Symbolically expressed, the speed of light c equals frequency f multiplied by wavelength lambda, holding strictly true across all electromagnetic spectra.

57. (D) Frequency
Frequency is an intrinsic property determined entirely by the source producing the light wave. When light transitions across a boundary into a medium of different optical density, its velocity and wavelength change proportionally according to the wave equation. However, the number of wave cycles passing a point per second remains strictly constant.

58. (A) The principal focus
Rays originating from an infinitely distant light source travel parallel to each other and to the principal axis of a concave mirror. Upon striking the reflecting surface, these parallel incident rays bounce inward according to reflection laws and converge precisely at the principal focus, forming a point-sized, real, and inverted image.

59. (B) Vacuum
Absolute refractive index measures optical density by comparing light velocity in a vacuum against its velocity in a given medium. A vacuum provides an unattenuated baseline standard where light travels at maximum theoretical speed. Defining refractive index strictly relative to vacuum ensures an absolute, reproducible scale independent of external atmospheric variations.

60. (B) Reversed from the primary rainbow
Secondary rainbows form higher in the sky when light undergoes two internal reflections within raindrops rather than one. This extra internal reflection reverses the angular exit geometry of constituent spectral rays. Consequently, red light appears on the inner boundary while violet light forms the outer edge, completely reversing the color order.

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61. (B) Three
A standard optical glass prism is a solid geometric polyhedron consisting of two parallel triangular bases located at opposite ends and three rectangular lateral faces inclined toward each other. Refraction and dispersion occur when light enters through one lateral face and emerges through another, making the three rectangular surfaces structurally essential.

62. (C) 90 degrees
Critical angle defines the threshold for total internal reflection when light travels from an

optically denser to a rarer medium. It represents the specific angle of incidence in the denser medium that refracts light along the boundary interface, producing an angle of refraction of exactly ninety degrees in the rarer medium.

63. (D) Infinite
The number of images formed by two plane mirrors inclined at angle theta is given by three hundred sixty divided by theta minus one. When mirrors are set parallel, theta equals zero degrees. Division by zero yields an infinite value, as light rays reflect back and forth endlessly between parallel surfaces.

64. (C) Planets are closer to Earth, so variations in atmospheric refraction average out.
Planets are significantly closer to Earth than distant stars, appearing as extended disk-like light sources composed of numerous individual point sources. Atmospheric turbulence causes light rays from different points of the disk to fluctuate independently. These variations continuously cancel each other out, producing a stable total light intensity and preventing twinkling.

65. (A) P-1, Q-2, R-3, S-4
Within the visible spectral range, red light features the maximum wavelength near seven hundred nanometres. Violet light possesses the minimum wavelength near four hundred nanometres. Green light falls in an intermediate spectral position between blue and yellow, while yellow occupies an intermediate wavelength band situated directly in between green and orange.

66. (D) Real, inverted, and magnified
When an object is placed between the focus and centre of curvature of a concave mirror, reflected rays intersect beyond the centre of curvature. Because the rays physically converge, the formed image is real and inverted. Furthermore, the image distance exceeds the object distance, yielding a magnification magnitude greater than one.

67. (A) Rectilinear propagation
Light travels through a uniform transparent medium along straight trajectories, a fundamental behavior known as rectilinear propagation. In a pinhole camera, light rays originating from different points of an object pass through a tiny aperture without crossing path distortions, directly projecting an inverted image onto a screen placed opposite the pinhole.

68. (B) I and III only
Refractive index is defined as vacuum light speed divided by medium light speed. Because light travels fastest in vacuum, this ratio always exceeds one for physical transparent media. Being a ratio of identical units, refractive index is dimensionless. Higher refractive indices correspond to optically denser media, validating statements one and three.

69. (A) It is highly coherent and monochromatic.
Laser light possesses extreme spatial and temporal coherence, meaning emitted light waves maintain identical phase relationships over time and space. Furthermore, laser emission is highly monochromatic, containing a single precise spectral wavelength. These combined properties allow laser beams to focus into sharp points of high energy density for precision surgical procedures.

70. (D) Dispersion
Monochromatic light consists of a single pure wavelength and single spectral frequency. When passing through a glass prism, monochromatic light refracts at boundaries, changes propagation speed inside the medium, and undergoes overall angular deviation. However, because dispersion requires separating multiple constituent wavelengths, dispersion cannot occur when illuminating with monochromatic light.

71. (B) Pole
The central geometric midpoint of the curved reflecting surface of a spherical mirror is defined as its pole. Symbolized by the letter P, the pole lies directly on the physical mirror surface. It serves as the primary origin point for establishing coordinate measurements and sign conventions under Cartesian optical analysis.

72. (C) Fermat's Principle
Fermat's Principle of Least Time states that out of all possible geometric paths connecting two points, a light ray traverses the path that requires the shortest overall time duration. This variational principle serves as a fundamental foundation in geometrical optics, directly deriving the classical laws of reflection and Snell's law of refraction.

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73. (A) 2, 3, 4, 1
As a light ray strikes a glass prism, refraction occurs first at the initial air-glass boundary. Differential refraction immediately causes the light ray to split into constituent spectral colours. These dispersed rays travel through the solid glass body before finally emerging into surrounding air through the second refracting face in proper sequence.

74. (D) The fourth power of the wavelength
Rayleigh scattering applies when incident light interacts with atmospheric scattering particles much smaller than its optical wavelength. Lord Rayleigh established mathematically that scattered light intensity is inversely proportional to wavelength raised to the fourth power. Consequently, shorter wavelengths like blue scatter far more efficiently than longer wavelengths like red under normal atmospheric conditions.

75. (B) Spectrum
Passing composite white light through a dispersive glass prism separates it into its component monochromatic wavelengths due to differential refraction. The resulting ordered array of seven continuous color bands displayed on a viewing screen—comprising red, orange, yellow, green, blue, indigo, and violet—is defined as an optical spectrum.

76. (B) One
Primary rainbows form through a precise combination of optical interactions as sunlight strikes suspended atmospheric raindrops. Incident sunlight refracts upon entering the spherical water droplet, undergoes dispersion into component wavelengths, reflects exactly once off the back inner surface of the droplet, and refracts again while exiting toward the observer's eye.

77. (A) 0 degrees
Normal incidence means the incoming light ray travels along the normal line perpendicular to the refracting interface, making the angle of incidence zero degrees. According to Snell's law, when incidence angle is zero, sine of incidence angle equals zero, making the angle of refraction zero degrees as light proceeds completely undeviated.

78. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Optical fibres consist of high refractive index glass cores enclosed by lower refractive index cladding. Light launched inside encounters core-cladding boundaries at incident angles exceeding the critical angle, causing repeated total internal reflections. This mechanism confines light inside the core, enabling long-distance data transmission with virtually no light energy leakage.

79. (C) Exactly 1
In a rectangular glass slab with parallel refracting faces, light refracts toward the normal at the first air-glass boundary and refracts away from normal by an identical angle upon emerging back into air. Consequently, the angle of emergence equals the angle of incidence, making the ratio of their sines exactly one.

80. (C) 4 metres
A plane mirror forms a virtual image situated behind the mirror surface at a distance equal to the distance of the object standing in front. If a person stands two metres in front of the mirror, the image forms two metres behind it, making the total separation distance equal four metres.

81. (B) Air
The phase speed of light in any optical medium is inversely proportional to its absolute refractive index. Among the given options, air has the lowest refractive index of approximately 1.0003, compared to water at 1.33, glass around 1.50, and diamond at 2.42. Thus, light travels fastest through air.

82. (A) P-2, Q-1, R-4, S-3
Plane mirrors primary exhibit regular specular reflection to produce clear virtual images. Rectangular glass slabs cause lateral displacement of emerging rays without angular deviation. Glass prisms induce significant angular deviation and chromatic dispersion of white light. Raindrop droplets create rainbows through a combination of dispersion, total internal reflection, and refraction.

83. (A) Spectrometer
A spectrometer is a specialized optical instrument designed to measure properties of light across a specific portion of the electromagnetic spectrum. Utilizing either a glass prism or diffraction

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grating, it spatially separates incoming radiation into individual constituent wavelengths, allowing accurate quantitative spectral intensity measurements and detailed chemical elemental analysis.

84. (C) Convex mirror
A spherical mirror formed by cutting a section of a hollow glass sphere whose outer bulging surface acts as the reflecting face is classified as a convex mirror. Incident parallel light rays striking its outward-curving surface reflect outwards and diverge, creating virtual focal points located behind the mirror structure.

85. (A) The moon is much closer to Earth than the stars.
Distant stars approximate single point sources, so atmospheric refractive index fluctuations cause large relative variations in light intensity entering the human eye, producing twinkling. In contrast, the moon is much closer to Earth, subtending a larger angular size as an extended source. Brightness fluctuations across its disk average out completely, preventing twinkling.

86. (D) Violet/Blue
According to Rayleigh's law of scattering, the fraction of light scattered by atmospheric air molecules is inversely proportional to the fourth power of wavelength. Violet and blue wavelengths are the shortest in the visible spectrum and experience the most intense scattering, imparting a blue hue to the sky under direct sunlight.

87. (B) Increases
An optically denser medium possesses a higher refractive index, significantly retarding light velocity. When light travels across an interface into an optically rarer medium with a lower refractive index, media resistance decreases. Consequently, the propagation speed of the light wave increases while its wave frequency remains strictly constant.

88. (C) Greater than the critical angle
Total internal reflection occurs exclusively when light propagates from a dense to a rarer medium. At the critical angle of incidence, refracted light travels along the boundary surface. When the incident angle strictly exceeds this critical angle limit, refraction ceases entirely, forcing all light to reflect internally back into the denser medium.

89. (D) I, II, and III
Rainbows form opposite the sun because water droplets reflect light backward. In primary rainbows, single internal reflections inside droplets disperse red rays at a forty-two degree angle and violet rays at forty degrees relative to sunlight. Consequently, red light forms the upper outer rim while violet light forms the lower inner rim.

90. (A) Optical fibre
Periscopes, kaleidoscopes, and shaving mirrors operate through partial or total light reflection off mirror surfaces. In contrast, optical fibres rely primarily on total internal reflection, which is a specialized phenomenon occurring during refraction at core-cladding boundaries. Therefore, optical fibres are classified under internal refraction phenomena rather than standard external reflection applications.

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91. (B) At the centre of curvature
For a concave mirror, placing a physical object directly at the centre of curvature results in light rays converging at the exact same location after reflection. The resulting image produced is real, inverted, and precisely equal in height to the object, yielding a linear magnification magnitude of negative one.

92. (A) 2.25×10^8 m/s
Light speed in a medium equals vacuum light speed divided by the absolute refractive index of that medium. Dividing three times ten to the power of eight metres per second by a refractive index of 1.33 yields approximately two point two five times ten to the power of eight metres per second in water.

93. (A) Refractive index
A glass prism separates white light into its constituent colors because glass exhibits chromatic dispersion. This property means that the refractive index of glass varies with light wavelength, being higher for shorter wavelengths like violet and lower for longer wavelengths like red. This variation causes different colors to refract by distinct angles.

94. (C) There is no atmosphere in space to scatter sunlight.
The daytime sky on Earth appears bright and blue due to Rayleigh scattering of sunlight by atmospheric gas molecules. In outer space, a

complete vacuum exists with no surrounding atmosphere. Because no air particles or dust are present to scatter sunlight toward an observer's eyes, space appears completely black except for direct celestial light.

95. (A) P-1, Q-2, R-3, S-4
In the new Cartesian sign convention, light travels from left to right. Real objects lie in front of mirrors, making object distance always negative. Concave mirror focal length and real image distance lie in front, so both are negative. Real images form below the principal axis, so image height is also negative.

96. (B) 2/3
The relative refractive index between two transparent media is strictly reciprocal when reversing the light propagation path. If the refractive index of glass with respect to air is three over two, then by the principle of optical reversibility, the refractive index of air with respect to glass is its inverse, which equals two over three.

97. (B) Identical in phase, frequency, and direction
Stimulated emission is the fundamental quantum process where an incoming photon interacts with an excited atomic electron, inducing it to transition to a lower energy state. The newly emitted photon matches the incident photon identically in wavelength, frequency, direction of propagation, and phase, producing completely coherent laser light output.

98. (A) White light enters atmosphere → Shorter wavelengths scatter away → Red light reaches the observer
During sunrise, sunlight travels through a maximum path thickness of Earth's atmosphere. Air molecules scatter shorter blue and violet wavelengths in all directions away from the direct line of sight. Longer red wavelengths suffer minimal scattering, passing directly through the thick atmospheric layer to reach the observer's eye, imparting a reddish appearance.

99. (A) Total internal reflection
Endoscopes utilize flexible bundles of optical fibers to transmit light into internal body cavities and return reflected images to external displays. Light rays launched into optical fiber cores exceed the critical angle at core-cladding boundaries, undergoing repeated total internal reflections that guide light virtually losslessly along curved paths inside human organs.

100. (C) Virtual, erect, and magnified
Linear magnification indicates the ratio of image height to object height. A positive sign for magnification confirms that the image formed is upright or erect relative to the object, which corresponds to a virtual image in spherical mirror optics. A magnification magnitude of two demonstrates that the image is enlarged to twice the object's physical height.

101. (A) Aperture
The aperture of a spherical mirror represents the effective linear diameter of its circular reflecting boundary line. It defines the total surface area available to intercept and gather incident light rays. In geometric optical calculations, a small aperture relative to the radius of curvature minimizes spherical aberration, ensuring sharp image focus.

102. (B) Away from the normal
Water is optically denser than air, possessing a higher refractive index. When light rays travel from water into air, light propagation speed increases upon entering the rarer medium. In accordance with Snell's law, this increase in phase velocity forces refracted light rays to angle further outward, bending away from the normal line.

103. (B) Light travels a shorter distance, so scattering is minimal.
At noon, the sun is positioned directly overhead, so sunlight traverses the shortest vertical path length through Earth's atmosphere. Because the atmospheric travel distance is minimal, atmospheric scattering of shorter blue and violet wavelengths is significantly reduced compared to sunrise or sunset, allowing all visible colours to reach the eye almost equally and appear white.

104. (C) Concave mirror
Concave mirrors are converging optical surfaces that collect parallel incoming sunlight rays and reflect them toward a single principal focal point. When used in solar cookers, large concave reflectors focus incoming solar radiation onto a small concentrated focal region, generating the extremely high temperatures required for efficient thermal heating and cooking.

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105. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Diamond possesses a high refractive index of 2.42, giving it a critical angle of only twenty-four degrees. Light entering a properly cut diamond strikes internal facets at angles greater than this small critical angle, causing repeated total internal reflections. This internal light entrapment before exit produces brilliant sparkle, fully validating both statements.

106. (A) Virtual and erect
Convex mirrors possess a diverging optical surface that forms virtual, upright, and diminished images for all real object positions placed along the principal axis. Regardless of whether an object is situated inside or outside the numerical focal distance, reflected light rays diverge, extending backward to intersect behind the mirror surface.

107. (B) Principal axis
The principal axis is an imaginary reference line passing perpendicularly through both the pole and centre of curvature of a spherical mirror. Normal rays travelling along this line strike the mirror at zero incidence angle and reflect directly back along the same path, serving as the central axis for ray diagrams.

108. (B) Indigo
VIBGYOR is a standard memory mnemonic representing the seven constituent spectral colors of visible light produced when compound white light undergoes chromatic dispersion through a glass prism. In this ordered sequence, the letter 'I' stands for Indigo, situated in the visible wavelength spectrum between blue and violet light.

109. (A) P-2, Q-1, R-4, S-3
Barcode scanners utilize monochromatic coherent laser beams to read optical data accurately. Counterfeiting currency detection uses ultraviolet light to reveal hidden fluorescent security features. Telecommunication cables rely on total internal reflection within optical fibers for high-speed signal transmission. Viewing microscopic structures requires refraction through optical glass lenses in microscope systems.

110. (C) All reflecting surfaces regardless of shape
The fundamental laws of reflection state that the angle of incidence equals the angle of reflection, and the incident ray, reflected ray, and normal lie in the same plane. These laws apply universally to all reflecting surfaces, including flat plane mirrors, spherical concave and convex surfaces, and highly irregular rough boundaries.

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111. (D) Presence of water droplets acting as tiny prisms
Rainbow formation requires atmospheric water droplets suspended in air following or during light rain. These spherical water drops act as small natural glass prisms. Sunlight entering droplets undergoes refraction, dispersion into spectral colors, internal reflection off the back surface, and secondary refraction upon exiting, generating the observable circular rainbow arc.

112. (A) I and II only
The Tyndall effect is light scattering caused by colloidal particles, visible when light passes through a colloidal suspension or a sunbeam enters a dusty smoky room. However, the black sky seen by astronauts results from the total absence of an atmosphere in space, not the Tyndall effect, confirming statements one and two.

113. (B) Dark / Black
Sunlight appears blue during daytime on Earth because gas molecules and aerosol particles in the atmosphere scatter shorter blue wavelengths. Without an atmospheric gas layer surrounding Earth, light rays from the sun would travel in straight paths without atmospheric scattering, causing the sky to appear dark black even during daylight hours.

114. (D) Nature of the medium
Refractive index is an intrinsic optical characteristic determined by the chemical composition and structural nature of the medium, as well as the incident light wavelength. It remains independent of external physical factors such as sample geometric shape or incidence angle, reflecting the optical density inherent to that specific material substance.

115. (A) Optically rarer medium
Solar heating increases the surface temperature of desert ground, heating air layers directly above it. Because thermal expansion decreases

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air density, warm ground air becomes less dense than cooler air above. Consequently, warm ground air behaves as an optically rarer medium, causing downward light rays to continually refract away from the normal.

116. (C) The chemical composition of a light source
Emission spectroscopy analyzes light emitted by excited atoms, ions, or molecules as electrons transition to lower energy levels. Because every chemical element possesses unique, quantized electronic energy level configurations, emitted spectral line frequencies serve as characteristic atomic fingerprints, enabling precise determination of the chemical composition of light sources.

117. (C) 0 degrees
When a light ray strikes a plane mirror surface perpendicularly, it aligns directly with the normal line at the point of incidence, making the angle of incidence zero degrees. By the law of reflection, the angle of reflection strictly equals the angle of incidence, so it is also exactly zero degrees.

118. (A) P-3, Q-1, R-2, S-4
Three times ten to the power of eight metres per second represents the propagation speed of light in a vacuum. Water has a refractive index of roughly 1.33. Diamond features a high optical refractive index of 2.42. Light cannot propagate through a completely opaque medium, resulting in zero light propagation speed.

119. (B) Incandescent solids, liquids, or dense gases
A continuous spectrum contains an unbroken array of visible light wavelengths without dark gaps or discrete lines. This spectral emission occurs when dense matter, such as incandescent solids, liquids, or highly compressed hot gases, emits thermal radiation, as thermal molecular collisions produce energy states across a continuous wavelength distribution band.

120. (C) Formation of dark shadows
Rectilinear propagation dictates that light travels along straight path trajectories through uniform transparent media. When an opaque object blocks incoming light rays, the obstructed light rays cannot curve around object edges, creating a dark region of shadow behind the object. This shadow formation provides direct empirical proof of straight-line light propagation.

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CHAPTER 07

Lenses and Vision Defects

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1. A transparent medium bound by two surfaces, of which at least one is spherical, is called a:
(A) Mirror
(B) Lens
(C) Prism
(D) Slab

2. Which of the following describes the physical structure of a standard convex lens?
(A) Thicker in the middle and thinner at the edges
(B) Thicker at the edges and thinner in the middle
(C) Having a completely uniform thickness throughout
(D) Featuring flat and parallel surfaces on both sides

3. What type of image is typically formed by a concave lens for a real object?
(A) Real, inverted, and magnified
(B) Virtual, erect, and magnified
(C) Virtual, erect, and diminished
(D) Real, erect, and diminished

4. Which of the following represents the correct standard lens formula relating object distance (u), image distance (v), and focal length (f)?
(A) $1/f = 1/v + 1/u$
(B) $1/f = 1/u - 1/v$
(C) $f = v + u$
(D) $1/f = 1/v - 1/u$

5. The SI unit of power of a lens is:
(A) Meter
(B) Watt
(C) Dioptre
(D) Joule

6. A convex lens is also known by which of the following terms?
(A) Diverging lens
(B) Converging lens
(C) Cylindrical lens
(D) Bifocal lens

7. The sensitive layer at the back of the human eye where the image is formed is called the:
(A) Cornea
(B) Iris
(C) Pupil
(D) Retina

8. Match List I with List II:
List I: (Eye part)
P. Iris
Q. Pupil
R. Retina
S. Ciliary muscles
List II: (Function)
1. Adjusts the focal length of the eye lens
2. Acts as a screen for image formation
3. Controls the amount of light entering the eye
4. Regulates the size of the pupil
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

9. What is the normal range of vision for a healthy young human eye?
(A) 0 cm to 25 cm
(B) 25 cm to 100 cm
(C) 25 cm to infinity
(D) 10 m to infinity

10. The ability of the eye lens to adjust its focal length to see objects at various distances is called:
(A) Accommodation
(B) Resolution
(C) Magnification
(D) Persistence of vision

11. What is the near point (least distance of distinct vision) for a young adult with normal vision?
(A) 2.5 cm
(B) 25 cm
(C) 50 cm
(D) 100 cm

12. Consider the following statements regarding myopia (near-sightedness):

101. What is the magnifying power of a telescope if the focal length of its objective is 100 cm and that of the eyepiece is 5 cm?
(A) 5
(B) 20
(C) 105
(D) 500

102. What type of lens is formed by an air bubble trapped inside a solid glass block?
(A) Convex lens (Converging)
(B) Concave lens (Diverging)
(C) Plano-convex glass lens
(D) Standard cylindrical lens

103. In older adults, presbyopia is often accompanied by which other common refractive error, necessitating the use of bifocals?
(A) Colour blindness
(B) Cataract
(C) Trachoma
(D) Hypermetropia

104. When a person is tested for spectacles and given a prescription of "-1.50 D Cyl at 90 degrees", they are primarily being treated for:
(A) Astigmatism
(B) Myopia only
(C) Presbyopia
(D) Cataract

105. Consider the following statements regarding the human eye structure:
I. The sclera forms the opaque, tough white outer covering of the eye.
II. The choroid supplies blood to the eye tissues.
III. The cornea is entirely opaque to protect the pupil.
Which of the given statements is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II, and III

106. In an optical diagram, a real and inverted image formed by a lens is always placed:
(A) Above the principal axis
(B) Below the principal axis
(C) Directly on the optical centre
(D) At an infinite distance away

107. The transparent protective membrane that lines the inner surface of the eyelid and covers the white part of the eye is the:
(A) Neural retina
(B) Pigmented iris
(C) Central macula
(D) Conjunctiva

108. When you walk from a bright sunny street into a dark cinema hall, you cannot see clearly for a short time. Which part of the eye is adjusting to allow more light in?
(A) Cornea
(B) Pupil
(C) Retina
(D) Optic nerve

109. If an object is placed at the principal focus of a concave lens, where is the image formed?
(A) At an infinite distance away from the lens
(B) Positioned exactly at the center of curvature
(C) Between the focus and the optical centre
(D) Far beyond twice the focal length (2F)

110. Consider the following lenses with their focal lengths given:
I. A lens of focal length +10 cm
II. A lens of focal length +25 cm
III. A lens of focal length +50 cm
IV. A lens of focal length +100 cm
Which of the following options arranges these lenses in decreasing order of their convergence power?
(A) I, II, III, IV
(B) IV, III, II, I
(C) II, I, IV, III
(D) III, IV, I, II

111. The phenomenon of splitting of white light into its constituent colours by a prism or lens edge is called:
(A) Dispersion
(B) Reflection
(C) Total Internal Reflection
(D) Diffraction

112. Why are modern high-power spectacle lenses often made from materials with a high refractive index?
(A) To allow them to filter out all visual light colors except green
(B) So they can be made much thinner and lighter than standard glass
(C) To provide an effective therapeutic treatment for colour blindness
(D) To significantly increase the apparent visual size of the eye lens

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Which of the following options is correct?
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

25. A simple microscope essentially consists of a:
(A) Low-power concave lens
(B) High-power concave lens
(C) High-power convex lens
(D) Low-power cylindrical lens

26. In a standard astronomical telescope used for seeing distant stars, the objective lens is a:
(A) Convex lens of large focal length and large aperture
(B) Concave lens of short focal length and small aperture
(C) Convex lens of short focal length and small aperture
(D) Concave lens of large focal length and large aperture

27. The working principle of a camera is most similar to which human sensory organ?
(A) Ear
(B) Nose
(C) Skin
(D) Eye

28. In a camera, which part serves a function similar to the retina of the human eye?
(A) Mechanical shutter
(B) Photographic film
(C) Adjustable aperture
(D) Optical camera lens

29. A magnifying glass creates an image that is:
(A) Real, inverted, and magnified
(B) Real, erect, and diminished
(C) Virtual, erect, and magnified
(D) Virtual, inverted, and diminished

30. Choose the correct sequence of light traveling through the structural components of the human eye:
(A) Cornea → Pupil → Lens → Retina
(B) Pupil → Cornea → Retina → Lens
(C) Cornea → Lens → Pupil → Retina
(D) Lens → Cornea → Pupil → Retina

31. What is the focal length of a convex lens whose power is +2.0 D?
(A) +0.5 cm
(B) +50 cm
(C) +2.0 m
(D) +20 cm

32. Which of the following is the most effective and widely used surgical treatment for cataracts?
(A) Daily topical administration of prescription antibiotic eye drops
(B) Surgical removal of the clouded lens and intraocular lens implantation
(C) Continuous non-invasive usage of high-power corrective convex lenses
(D) Advanced laser-assisted surgical reshaping of the outer corneal surface

33. Which popular laser eye surgery is used to correct refractive errors like myopia by reshaping the cornea?
(A) Cataract extraction
(B) LASIK
(C) Retinal detachment surgery
(D) Glaucoma drainage

34. High exposure to ultraviolet (UV) radiation from sunlight significantly increases the risk of which eye condition?
(A) Cataract
(B) Colour blindness
(C) Astigmatism
(D) Hypermetropia

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35. Consider the following statements about power of lenses:
I. The power of a convex lens is positive.
II. The power of a concave lens is negative.
III. If a convex lens and concave lens of equal focal lengths are combined, the net power is zero.
Which of the given statements is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II, and III

36. If two thin lenses of power P_1 and P_2 are placed in contact, their equivalent power P is given by:
(A) $P = P_1 - P_2$
(B) $P = P_1 \times P_2$
(C) $P = P_1 / P_2$
(D) $P = P_1 + P_2$

37. Which term describes the center point of a lens through which a ray of light passes without any deviation?

(A) Principal focus
(B) Centre of curvature
(C) Optical centre
(D) Pole

38. For an object placed between the optical centre and principal focus of a convex lens, the image formed is:
(A) Real, inverted, and diminished
(B) Virtual, erect, and magnified
(C) Real, inverted, and same size
(D) Virtual, erect, and diminished

39. What type of image is formed by the objective lens of a compound microscope?
(A) Virtual, erect, and diminished
(B) Virtual, inverted, and magnified
(C) Real, erect, and diminished
(D) Real, inverted, and magnified

40. Match List I with List II:
List I: (Optical Instrument)
P. Simple microscope
Q. Compound microscope
R. Astronomical telescope
S. Camera
List II: (Use/Feature)
1. Two convex lenses, used to view tiny objects like cells
2. Has an aperture to control light and captures a permanent image
3. Two convex lenses, used to view distant celestial bodies
4. Single convex lens used by watchmakers
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

41. Identify the incorrect statement regarding the human eye:
(A) The cornea provides most of the eye's refractive power.
(B) The pupil expands in dim light.
(C) The image formed on the retina is virtual and erect.
(D) Ciliary muscles change the shape of the lens.

42. In a bifocal lens prescribed for a patient suffering from both myopia and presbyopia, how are the lenses arranged?
(A) Upper part is concave, lower part is convex
(B) Upper part is convex, lower part is concave
(C) Both upper and lower parts are cylindrical
(D) Both parts are convex with different powers

43. Which photosensitive cells in the human retina are responsible for colour vision?
(A) Rods
(B) Ganglion cells
(C) Bipolar cells
(D) Cones

44. The fluid present between the cornea and the eye lens is called:
(A) Vitreous humor
(B) Aqueous humor
(C) Synovial fluid
(D) Tear fluid

45. Consider the following steps of image formation in a camera:
I. Light hits the photosensitive film/sensor to record the image.
II. Light rays reflect off the subject.
III. Light enters through the aperture.
IV. The lens focuses the light rays.
Which of the following represents the correct functional order of these steps?
(A) II, III, IV, I
(B) III, II, IV, I
(C) IV, III, II, I
(D) II, IV, III, I

46. A concave lens always forms an image that is:
(A) Real and inverted
(B) Virtual, erect, and magnified
(C) Real, erect, and diminished
(D) Virtual, erect, and diminished

47. By standard sign convention, the focal length of a concave lens is considered:
(A) Negative
(B) Positive
(C) Zero
(D) Infinite

48. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): A person suffering from myopia wears glasses with a negative power.
Reason (R): Myopia is corrected with a concave lens, which has a negative focal length.
Which of the following options is correct?
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.

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(D) Assertion (A) is false but Reason (R) is true.

49. The blind spot in the human eye is the region where:
(A) Photoreceptor cells consisting exclusively of sensitive rods are present
(B) The optic nerve leaves the eye and there are no photoreceptor cells
(C) Maximum visual acuity and image resolution naturally occur in the eye
(D) Ciliary muscles attach directly to the crystalline optical eye lens

50. Match List I with List II:
List I: (Term)
P. Far point
Q. Near point
R. Power
S. Magnification
List II: (Definition)
1. Minimum distance at which objects can be seen clearly without strain
2. Farthest point up to which the eye can see clearly
3. Ratio of the height of the image to the height of the object
4. Reciprocal of focal length in meters
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

51. The colored part of the eye that gives a person their specific eye color (e.g., brown, blue) is the:
(A) Cornea
(B) Pupil
(C) Iris
(D) Sclera

52. Which defect occurs when the focal length of the eye lens becomes too long?
(A) Myopia
(B) Cataract
(C) Colour blindness
(D) Hypermetropia

53. If a student sits in the last row of a classroom and cannot read the blackboard clearly, but can easily read a book on her desk, she is suffering from:
(A) Hypermetropia
(B) Presbyopia
(C) Myopia
(D) Astigmatism

54. What happens to the ciliary muscles when the eye focuses on a nearby object?
(A) They relax and make the lens thinner
(B) They contract and make the lens thicker
(C) They detach completely from the eye lens
(D) They push the neural retina further forward

55. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): Colour blindness cannot be cured by wearing spectacles or contact lenses.
Reason (R): Colour blindness is a genetic condition related to the absence or malfunction of cone cells in the retina.
Which of the following options is correct?
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

56. The jelly-like substance that fills the space between the lens and the retina, maintaining the spherical shape of the eye, is called:
(A) Vitreous humor
(B) Aqueous humor
(C) Endolymph fluid
(D) Perilymph fluid

57. What is the central aperture in the iris called?
(A) Cornea
(B) Macula
(C) Pupil
(D) Fovea

58. Consider the following statements about contact lenses:
I. They can be used as an alternative to spectacles for correcting refractive errors.
II. They rest directly on the cornea.
III. Soft contact lenses are typically made from water-absorbing hydrogel plastics.
Which of the given statements is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I
(D) I, II and III

59. Which of the following best describes 'Persistence of vision' in humans?
(A) The specialized physiological capability to clearly perceive objects in completely dark rooms

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2. Impact-resistant and lightweight material
3. Concave lens for distant vision
4. Reduces glare from bright sunlight

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-4, S-3

81. Consider the following statements about astigmatism:
I. It causes blurring of lines in certain directions.
II. It is corrected by using a cylindrical lens.
III. It happens when the eye lens becomes milky and cloudy.
Which of the given statements is/are correct?
(A) Only I
(B) Only I and II
(C) Only II and III
(D) I, II, and III

82. Which feature of the human eye prevents internal reflection of light?
(A) Dark choroid layer
(B) Opaque sclera layer
(C) Protective conjunctiva
(D) Transparent cornea

83. Why do photographers use lenses with different focal lengths (like telephoto or wide-angle lenses) on cameras?
(A) To alter and enhance the color tones of the final image
(B) To increase the physical recording capacity of the camera film
(C) To capture subjects with varied fields of view and magnification
(D) To correct optical astigmatism distortions in the final photo

84. Which of the following best describes the image formed by the human eye on the retina?
(A) Virtual, erect, and diminished
(B) Real, erect, and magnified
(C) Virtual, inverted, and magnified
(D) Real, inverted, and diminished

85. Match List I with List II:
List I: (Object position for Convex Lens)
P. At infinity
Q. Beyond 2F
R. At 2F
S. Between F and Optical Centre
List II: (Image position)
1. Same side as object (virtual)
2. At focus F
3. Between F and 2F
4. At 2F

(A) P-2, Q-3, R-4, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-3, S-1
(D) P-3, Q-2, R-4, S-1

86. Find the odd one out among the following eye conditions based on their typical correction method:
(A) Simple myopia
(B) Colour blindness
(C) Hypermetropia
(D) Age presbyopia

87. If you look at an object through a lens and the image appears smaller and erect regardless of the distance, the lens is definitely:
(A) Convex
(B) Cylindrical
(C) Plano-convex
(D) Concave

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88. A student uses a convex lens of focal length 10 cm as a magnifying glass. To get the maximum magnification for clear vision, the image should be formed at:
(A) The near point (25 cm)
(B) Infinite distance
(C) The focal point (10 cm)
(D) The optical centre of lens

89. Which part of the eye is responsible for converting light energy into electrical nerve impulses?
(A) Pupil
(B) Optic nerve
(C) Retina
(D) Sclera

90. Consider the following stages of cataract treatment:
I. Implantation of artificial Intraocular Lens (IOL)
II. Breaking up and removal of the cloudy natural lens
III. Local anesthesia applied to the eye
IV. Making a small incision in the cornea
Which of the following represents the correct order of these stages?
(A) III, IV, II, I
(B) IV, III, II, I
(C) II, IV, I, III

70. In the context of vision testing, what does the Snellen chart typically measure?
(A) Genetic colour blindness defects
(B) Visual acuity (sharpness of vision)
(C) Astigmatism axis and orientation
(D) Intraocular fluid pressure level

71. Identify the incorrect statement regarding optical lenses:
(A) A concave lens always forms a diminished image.
(B) The optical centre is a point where light rays pass undeviated.
(C) Lens formula applies to both convex and concave thin lenses.
(D) A convex lens cannot form a virtual image under any condition.

72. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): To achieve high magnification, a compound microscope uses two lenses.
Reason (R): The total magnification is the sum of the magnifications of the objective lens and eyepiece.
Which of the following options is correct?
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

73. Which of the following is true for an object placed at infinity in front of a convex lens?
(A) The image is formed at 2F on the other side and is of the exact same size
(B) The image formed is entirely virtual, erect, and highly magnified in size
(C) The image is formed at the principal focus (F) and is highly diminished
(D) No image is formed at any real or virtual location behind the convex lens

74. Which of the following laser types is most commonly used in LASIK eye surgery for reshaping the cornea?
(A) Excimer laser
(B) Ruby laser
(C) Nd:YAG laser
(D) Helium-Neon laser

75. A medical condition where increased pressure inside the eye damages the optic nerve is known as:
(A) Cataract
(B) Trachoma
(C) Blepharitis
(D) Glaucoma

76. In an astronomical telescope at normal adjustment, the distance between the objective lens and eyepiece is equal to:
(A) fo × fe
(B) fo + fe
(C) fo / fe
(D) fo - fe

77. For an individual requiring spectacles of power +1.5 D, what does the positive sign indicate?
(A) The person suffers from myopia and requires a concave lens.
(B) The person suffers from cataract requiring surgical removal.
(C) The person suffers from hypermetropia and needs a convex lens.
(D) The person suffers from astigmatism and needs a cylindrical lens.

78. Which statement is correct regarding a person with hypermetropia?
(A) Their far point has moved significantly closer than infinity.
(B) Their near point has shifted much closer than normal 25 cm.
(C) Their far point has receded permanently back to infinity.
(D) Their near point has receded further away than 25 cm.

79. The light-sensitive cells in the eye that function optimally in dim light and are responsible for night vision are:
(A) Rods
(B) Cones
(C) Macula
(D) Cornea

80. Match List I with List II:
List I: (Spectacle Part/Type)
P. Bifocal upper part
Q. Bifocal lower part
R. Polycarbonate lens
S. Tinted/Polarized lens
List II: (Description)
1. Convex lens for reading

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(B) The gradual automatic adjustment of pupil size when stepping into dark rooms from bright sunlight
(C) The instantaneous flexibility of ciliary muscles to adjust the eye lens focal length constantly
(D) Retention of an image on the retina for about 1/16th of a second after the object is removed

60. Consider the following objects with their optical powers given:
I. P = +10 D
II. P = +5 D
III. P = +2 D
IV. P = +0.5 D
Which of the following options arranges these objects according to their typical focal lengths in increasing order (shortest to longest)?
(A) I, II, III, IV
(B) IV, III, II, I
(C) I, III, II, IV
(D) IV, II, III, I

61. For an object placed exactly at the center of curvature (2F) of a convex lens, the image formed is:
(A) Real, inverted, and significantly smaller than the object
(B) Virtual, erect, and highly magnified relative to the object
(C) Real, inverted, and of the exact same size as the object
(D) Real, inverted, and highly magnified relative to the object

62. Which of the following options represents a negative effect of not maintaining proper hygiene with contact lenses?
(A) Reversal of astigmatism
(B) Permanent change in eye color
(C) Prevention of cataracts
(D) Corneal infections and ulcers

63. A lens has a focal length of -50 cm. What is its power and type?
(A) -2.0 D, Concave lens
(B) +2.0 D, Convex lens
(C) -0.5 D, Concave lens
(D) +0.5 D, Convex lens

64. What is the role of an aperture in optical instruments like a camera or telescope?
(A) It continuously magnifies the incoming light rays and image.
(B) It controls the amount of light entering the optical instrument.
(C) It serves as the primary recording film or digital image sensor.
(D) It provides basic structural support to the outer optical casing.

65. Match List I with List II:
List I: (Value)
P. Infinity
Q. 25 cm
R. 1/16 second
S. 0 D (Zero Dioptre)
List II: (Eye Parameter)
1. Persistence of vision
2. Power of a flat glass plate
3. Near point of a normal eye
4. Far point of a normal eye
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-2, R-3, S-4

66. When light enters the human eye, the maximum amount of refraction occurs at the:
(A) Outer surface of the cornea
(B) Crystalline internal eye lens
(C) Transparent aqueous humor fluid
(D) Light-sensitive neural retina

67. If linear magnification (m) produced by a lens is negative, it indicates that the image is:
(A) Virtual and erect
(B) Real and erect
(C) Real and inverted
(D) Formed at infinity

68. What is the fundamental cause of presbyopia?
(A) Excessive elongation of the human eyeball causing light rays to focus early
(B) Congenital condition involving an irregularly shaped curved cornea from birth
(C) Total genetic absence or functional defect of cone cells in the human retina
(D) Weakening of ciliary muscles and reduced flexibility of the natural eye lens

69. Which type of lens can be used to start a fire by focusing sunlight onto a piece of paper?
(A) Concave lens
(B) Cylindrical lens
(C) Convex lens
(D) Diverging lens

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(D) III, II, IV, I

91. A lens manufacturer combines a convex lens of power +3 D with a concave lens of power -1 D. The resultant power of the combination is:
(A) -4 D
(B) +4 D
(C) +2 D
(D) -2 D

92. The region of the retina where visual acuity (sharpness of vision) is the highest is called the:
(A) Optic disc region
(B) Fovea centralis (Macula)
(C) Physiological blind spot
(D) Vascular choroid layer

93. What does "IOL" stand for in the context of eye surgery?
(A) Inner Optical Lens
(B) Integrated Ophthalmic Laser
(C) Intraocular Lens
(D) Internal Ocular Ligament

94. Identify the correct pair of optical instrument and its primary objective lens characteristic:
(A) Compound microscope - Objective lens has large focal length and aperture
(B) Simple microscope - Always constructed using a single concave optical lens
(C) Camera - Primary focusing lens system is always composed of a concave lens
(D) Astronomical telescope - Objective lens has large focal length and aperture

95. Match List I with List II:
List I: (Term)
P. Dioptre
Q. Cornea
R. LASIK
S. Snellen Chart
List II: (Associated concept)
1. Visual acuity measurement
2. Power of lens
3. Eye donation tissue
4. Laser eye surgery
(A) P-2, Q-3, R-4, S-1
(B) P-2, Q-4, R-3, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-4, Q-3, R-1, S-2

96. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): Having two eyes provides stereoscopic (3D) vision.
Reason (R): Because the eyes are separated by a few centimeters, each eye sees a slightly different angle of the object, which the brain merges to perceive depth.
Which of the following options is correct?
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

97. The defect where the curvature of the cornea is greater in one plane than in another is:
(A) Presbyopia
(B) Astigmatism
(C) Myopia
(D) Hypermetropia

98. Which of the following is NOT a recommended eye care precaution?
(A) Reading in dim light for long durations
(B) Washing eyes with clean water regularly
(C) Maintaining a distance of at least 25 cm while reading a book
(D) Blinking frequently when using computer screens

99. The straight line passing through the centres of curvature of the two surfaces of a lens is called its:
(A) Focal plane
(B) Optical centre
(C) Principal axis
(D) Radius vector

100. Match List I with List II:
List I: (Condition)
P. Cataract
Q. Myopia
R. Hypermetropia
S. Colour blindness
List II: (Symptom/Effect)
1. Difficulty seeing distant objects
2. Cloudy or milky vision
3. Inability to distinguish red and green
4. Difficulty seeing near objects
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

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I. A person with myopia can see nearby objects clearly.
II. In a myopic eye, the image of a distant object is formed behind the retina.
III. It can be corrected using a concave lens of appropriate power.
Which of the given statements is/are correct?
(A) Only I
(B) Both I and II
(C) Both I and III
(D) I, II and III

13. Which vision defect occurs when the eyeball becomes too long, causing light rays from distant objects to focus in front of the retina?
(A) Hypermetropia
(B) Astigmatism
(C) Myopia
(D) Cataract

14. Which lens is used to correct hypermetropia (far-sightedness)?
(A) Concave lens
(B) Cylindrical lens
(C) Plano-concave lens
(D) Convex lens

15. The condition where an elderly person's eye loses its power of accommodation, making it difficult to read near objects clearly, is termed:
(A) Presbyopia
(B) Astigmatism
(C) Colour blindness
(D) Myopia

16. What kind of lenses are required to correct presbyopia?
(A) Only concave lenses
(B) Bifocal lenses
(C) Only cylindrical lenses
(D) Tinted lenses

17. Astigmatism is a vision defect caused by:
(A) Gradual weakening of ciliary muscles
(B) Irregular curvature of the cornea
(C) Abnormal elongation of the eyeball
(D) Progressive clouding of the eye lens

18. Which optical device is prescribed to correct astigmatism?
(A) Cylindrical lens
(B) Standard convex lens
(C) Standard concave lens
(D) Triangular glass prism

19. A condition characterized by the clouding of the natural crystalline lens of the eye, commonly leading to blindness in old age, is:
(A) Glaucoma
(B) Trachoma
(C) Cataract
(D) Night blindness

20. Match List I with List II:
List I: (Vision Defect)
P. Myopia
Q. Hypermetropia
R. Presbyopia
S. Astigmatism
List II: (Corrective Lens)
1. Bifocal lens
2. Cylindrical lens
3. Convex lens
4. Concave lens
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

21. Which defect of vision is generally genetic and restricts a person from distinguishing between certain colours, typically red and green?
(A) Senile cataract
(B) Corneal astigmatism
(C) Colour blindness
(D) Age-related presbyopia

22. Which material is most commonly used today to manufacture lightweight spectacle lenses resistant to shattering?
(A) High-density heavy flint glass
(B) Polycarbonate / CR-39 plastic
(C) Naturally purified quartz crystal
(D) Heat-resistant tempered Pyrex glass

23. Contact lenses are directly placed on which part of the eye?
(A) Retina
(B) Pupil
(C) Sclera
(D) Cornea

24. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): Hypermetropia is corrected using a convex lens.
Reason (R): A convex lens provides additional converging power to focus the image exactly on the retina.

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113. A person reads a book keeping it at a distance of 50 cm. If his near point is 50 cm, what is the power of the reading glasses required so he can read at the normal near point of 25 cm?
(A) +1.0 D
(B) +2.0 D
(C) +3.0 D
(D) -2.0 D

114. The "red eye" effect commonly seen in flash photography is caused by:
(A) The reflection of camera flash off blood vessels in the retina
(B) The high-intensity light flash burning the cornea temporarily
(C) The natural glowing reaction of the iris under bright light
(D) A transient chemical reaction occurring inside the camera lens

115. Match List I with List II:
List I: (Animal vision characteristic)
P. Owls
Q. Eagles
R. Houseflies
S. Humans
List II: (Visual capability)
1. High density of rods for night vision
2. High density of cones for sharp daylight vision
3. Compound eyes giving a very wide field of view
4. Binocular vision with good depth perception
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

116. Which specific vitamin deficiency is a leading cause of preventable night blindness and poor corneal health?
(A) Vitamin C
(B) Vitamin K
(C) Vitamin D
(D) Vitamin A

117. An instrument that allows a doctor to look inside the eye to examine the retina and optic nerve is an:
(A) Diagnostic otoscope
(B) Standard stethoscope
(C) Ophthalmoscope
(D) Medical endoscope

118. Which statement best defines a 'virtual image' formed by a lens?
(A) It can easily be captured directly onto a physical projection screen
(B) It cannot be captured on a screen as light rays only appear to diverge
(C) It is always formed by the real and actual intersection of light rays
(D) It is always inverted in its orientation relative to the original object

119. A thick convex lens compared to a thin convex lens of the same material will have:
(A) A longer focal length and less power
(B) Exactly the same focal length and power
(C) A negative focal length and negative power
(D) A shorter focal length and more power

120. Which of the following is the most appropriate step to take if acid or a strong chemical accidentally splashes into the eyes during a chemistry lab experiment?
(A) Immediately flush eyes with abundant clean running water for several minutes
(B) Immediately rub both eyes vigorously with hands to remove chemical residues
(C) Wait quietly for natural lacrimal tears to wash out the chemical substance
(D) Apply a mild alkaline soap solution directly to neutralize the acidic chemical

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value indicates that the image height is negative, meaning the image formed by the lens is oriented upside down, signifying a real and inverted image.

68. (D) Weakening of ciliary muscles and reduced flexibility of the natural eye lens
Presbyopia is a natural age-related refractive defect caused by physiological changes in the eye. As individuals age, ciliary muscles gradually lose tone and strength while crystalline lens proteins harden, diminishing lens elasticity. This loss of accommodative capacity makes it difficult for the eye lens to thicken during close visual focusing.

69. (C) Convex lens
A convex lens functions as a converging optical system that refracts incoming parallel rays of sunlight inward toward a single focal point. Concentrating intense solar light energy and thermal radiation onto a small focal spot on a flammable surface like paper rapidly elevates its temperature, causing it to ignite fire.

70. (B) Visual acuity (sharpness of vision)
A Snellen chart is a standardized eye chart containing rows of block letters, known as optotypes, printed in progressively smaller sizes. Eye care professionals utilize this chart during clinical vision examinations to measure a person's visual acuity, determining their ability to discern fine spatial details from a standard viewing distance.

71. (D) A convex lens cannot form a virtual image under any condition.
A convex lens can readily form a virtual image under specific conditions. When an object is positioned closer to the lens than its principal focus, refracted rays diverge on the opposite side. Extending these rays backward forms an upright, enlarged, and virtual image on the same side as the object.

72. (C) Assertion (A) is true but Reason (R) is false.
Compound microscopes employ two convex lenses to achieve high magnification. The objective lens forms a magnified intermediate real image, which is subsequently magnified by the eyepiece. However, total system magnification is calculated as the product of individual lens magnifications, rather than their sum, making the reason statement mathematically incorrect.

73. (C) The image is formed at the principal focus (F) and is highly diminished
When an object is located at infinity, incoming light rays arriving at a convex lens are parallel to the principal axis. The lens refracts these parallel rays inward so they converge precisely at the principal focus on the far side, forming an inverted, real, and extremely diminished point-sized image.

74. (A) Excimer laser
LASIK procedures utilize an excimer laser, which emits high-energy pulsed ultraviolet radiation at a wavelength of 193 nanometers. This specialized laser breaks molecular bonds within corneal tissue via photoablation without causing thermal damage to adjacent optical structures, allowing precise micro-reshaping of the corneal curvature to correct refractive errors.

75. (D) Glaucoma
Glaucoma is a group of eye diseases characterized by pathologically elevated intraocular pressure, usually resulting from impaired drainage of aqueous humor fluid. High internal pressure causes progressive compression and irreversible structural damage to optic nerve fibers at the optic disc, leading to peripheral vision loss and potential total blindness.

76. (B) $f_o + f_e$
In an astronomical telescope adjusted for normal vision, light rays from a distant object enter the objective lens and form a real image at its focal point. The eyepiece is positioned so this intermediate image aligns with its focus, making the distance between lenses equal to the sum of their focal lengths.

77. (C) The person suffers from hypermetropia and needs a convex lens.
By standard sign convention, positive optical power corresponds to a lens with a positive focal length, which defines a convex converging lens. Convex lenses are used to correct hypermetropia by providing additional converging power to bring light rays from nearby objects to a focus directly on the retina.

78. (D) Their near point has receded further away than 25 cm.
In a hypermetropic eye, inadequate refractive power or a shortened eyeball causes light rays from near objects to focus behind the retina.

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eye without experiencing strain. For a young adult possessing normal vision, this standard distance is established as twenty-five centimeters from the front surface of the eye.

12. (C) Both I and III
Myopia, commonly known as near-sightedness, allows a person to see nearby objects clearly while distant objects appear blurry. In a myopic eye, rays from distant objects focus in front of the retina rather than directly on it. Placing a concave lens of suitable power in front of the eye corrects this error.

13. (C) Myopia
Myopia is a common refractive defect characterized by the inability to focus clearly on distant objects. This condition arises when the eyeball undergoes excessive elongation or when the optical curvature of the cornea and eye lens becomes overly sharp, causing parallel light rays from distance to converge in front of the retina.

14. (D) Convex lens
Hypermetropia, or far-sightedness, occurs when light rays from near objects converge behind the retina due to insufficient refractive power or a shortened eyeball. A convex lens provides additional converging power, bending incoming light rays inward before they reach the eye lens so that the final image forms precisely on the retina.

15. (A) Presbyopia
Presbyopia is an age-related refractive defect characterized by a progressive decline in the accommodation power of the human eye. As people grow older, the ciliary muscles weaken and the crystalline lens loses its natural flexibility. Consequently, focusing on nearby objects becomes difficult, shifting the near point further away than normal.

16. (B) Bifocal lenses
Presbyopia frequently affects elderly individuals who may simultaneously require correction for distant vision alongside near vision support. To address both refractive needs in a single frame, bifocal lenses are prescribed. The upper section contains a concave lens for viewing distant objects, while the lower section features a convex lens for reading.

17. (B) Irregular curvature of the cornea
Astigmatism is an optical refractive defect that occurs when the cornea or crystalline lens lacks a perfectly spherical curvature. Instead of being uniformly curved, the surface possesses uneven curvature across different meridians, preventing light rays from focusing onto a single sharp point on the retina, causing overall distorted or blurred vision.

18. (A) Cylindrical lens
Astigmatism is a refractive condition resulting from an uneven or asymmetrical curvature of the corneal surface across different axes. To correct this asymmetric focus, optical specialists prescribe cylindrical lenses. These lenses possess varying refractive powers along different planes, compensating for the irregular corneal shape and producing a single focused image.

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19. (C) Cataract
A cataract is a progressive medical condition characterized by the clouding and opacification of the natural crystalline eye lens. Typically associated with aging, accumulated protein aggregates obscure light transmission through the lens, resulting in blurred or hazy vision and potentially leading to total loss of sight if left untreated surgically.

20. (A) P-4, Q-3, R-1, S-2
Refractive errors of the human eye are corrected using distinct types of optical lenses. Myopia is corrected using a concave lens to diverge rays, hypermetropia requires a convex lens to converge rays, presbyopia is corrected using bifocal lenses for dual focus, and astigmatism relies on cylindrical lenses to correct irregular curvature.

21. (C) Colour blindness
Colour blindness is an inherited genetic condition characterized by a deficiency or total absence of specific cone photopigments in the retina. Individuals affected by this condition struggle to distinguish between specific wavelengths of light, most commonly experiencing difficulty in differentiating between shades of red and green under standard illumination conditions.

22. (B) Polycarbonate / CR-39 plastic
Modern spectacle lenses predominantly utilize advanced synthetic polymers such as CR-39 plastic and polycarbonate materials. These modern plastic materials offer significant

reflects off the target subject toward the camera lens system. Next, this light enters through the adjustable aperture, gets focused by the camera lens assembly, and ultimately strikes the photosensitive sensor or film to record the image.

46. (D) Virtual, erect, and diminished
A concave lens causes all incoming parallel light rays to diverge outwards upon refraction. Because these rays spread apart, they never physically intersect on the far side of the lens. Instead, their backward projections converge on the object side, forming an image that is consistently virtual, upright, and smaller in size.

47. (A) Negative
Under the standard Cartesian sign convention, distances measured against the direction of incoming light from the optical centre are assigned negative values. Since a concave lens diverges light rays such that its virtual principal focus lies on the same side as the object, its focal length is always designated as negative.

48. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Myopia is corrected using a concave lens because its diverging action counteracts excessive converging by the eye lens, relocating the focused image onto the retina. By standard sign convention, a concave lens possesses a negative focal length, resulting in a negative optical power value, validating both statements and their relationship.

49. (B) The optic nerve leaves the eye and there are no photoreceptor cells
The blind spot represents a specific structural region on the retina where ganglion cell axons bundle together to exit the eyeball as the optic nerve. Because this area contains zero rod or cone photoreceptor cells, any light focused onto this precise location cannot be detected, resulting in an absence of vision.

50. (A) P-2, Q-1, R-4, S-3
Key optical terms describe fundamental ocular properties. The far point is the maximum distance for clear focus, whereas the near point is the closest comfortable viewing distance. Optical power represents the reciprocal of focal length measured in meters, and magnification expresses the ratio between image height and object height.

51. (C) Iris
The iris is a pigmented, ring-shaped muscular structure situated behind the cornea and in front of the crystalline lens. Containing varying amounts of melanin pigment, it determines individual eye colour while dynamically controlling pupil diameter to regulate the intensity of light entering the inner eye chambers under varying lighting conditions.

52. (D) Hypermetropia
Hypermetropia, or far-sightedness, occurs when the focal length of the eye lens becomes excessively long or the eyeball becomes too short. Under these conditions, the refractive power of the eye lens is insufficient, causing light rays originating from nearby objects to focus behind the retina instead of directly on it.

53. (C) Myopia
Inability to read distant writing clearly while retaining the capacity to read nearby material easily is the classic clinical presentation of myopia. Light rays from distant objects are focused in front of the retina due to an elongated eyeball or excessive ocular refractive power, rendering distant visual details blurry and indistinct.

54. (B) They contract and make the lens thicker
When focusing on a nearby object, the ciliary muscles inside the eye contract, reducing tension on the suspensory ligaments. This relaxation allows the elastic crystalline eye lens to assume a more spherical, thicker shape, increasing its curvature and refractive power to ensure light rays converge properly onto the retina.

55. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Colour blindness stems from a congenital genetic abnormality affecting the photopigments inside retinal cone cells responsible for distinguishing specific wavelengths. Because corrective lenses only alter light refraction rather than restoring missing biological photoreceptors, spectacles cannot cure this genetic defect, making both statements accurate and logically aligned.

56. (A) Vitreous humor
Vitreous humor is a transparent, clear gelatinous fluid that occupies the large posterior cavity situated between the crystalline lens and the retina. Composed primarily of water, collagen, and hyaluronic acid, it exerts internal hydrostatic

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to permanently correct common refractive errors such as myopia, hypermetropia, and astigmatism without requiring spectacles.

34. (A) Cataract
Prolonged and unprotected exposure to high levels of solar ultraviolet radiation can accelerate oxidative stress and protein denaturation within the crystalline eye lens. Over time, these biochemical changes cause progressive clouding and opacification of the lens tissue, significantly elevating the risk of developing cataracts later in life.

35. (D) I, II, and III
Convex lenses have positive focal lengths and thus positive power, whereas concave lenses feature negative focal lengths and negative power. Combining a convex lens and a concave lens of identical absolute focal lengths results in equal and opposite powers, which cancel each other out to produce a net power of zero dioptres.

36. (D) $P = P_1 + P_2$
When two or more thin optical lenses are placed in direct contact along a common principal axis, their individual refractive effects combine algebraically. The total equivalent power of the combined lens system is equal to the simple sum of the individual lens powers, represented by the mathematical expression P equals P_1 plus P_2.

37. (C) Optical centre
The optical centre is a fixed geometric point located on the principal axis inside a lens. Any ray of light passing directly through this central point experiences equal refraction at both lens surfaces, resulting in zero net lateral deviation, allowing the light ray to emerge along its original path unchanged.

38. (B) Virtual, erect, and magnified
Placing an object between the optical centre and the principal focus of a convex lens causes refracted light rays to diverge on the far side. By extending these diverging rays backward, they meet on the same side as the object, producing an image that is virtual, upright, and larger than the original object.

39. (D) Real, inverted, and magnified
In a compound microscope, the objective lens is a short focal length convex lens positioned close to the specimen. The specimen is placed just beyond its principal focus, causing the objective lens to form an intermediate real, inverted, and enlarged image, which is then further magnified by the eyepiece.

40. (A) P-4, Q-1, R-3, S-2
Optical devices rely on specific lens configurations for dedicated applications. A simple microscope uses a single convex lens for magnification, a compound microscope combines two convex lenses for cellular observation, an astronomical telescope employs two convex lenses for viewing stars, and a camera includes an aperture to capture images onto film.

41. (C) The image formed on the retina is virtual and erect.
The crystalline lens of the human eye acts as a natural convex lens that focuses incoming light onto the retina, forming a real and inverted image. The brain subsequently processes these inverted neurological signals, reorienting the image so that objects are perceived in their true upright orientation.

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42. (A) Upper part is concave, lower part is convex
Bifocal lenses are designed to correct dual vision defects in individuals with presbyopia. The upper segment contains a concave lens to facilitate distant vision by diverging incoming rays, while the lower segment features a convex lens to provide necessary converging power for close-range tasks like reading fine print.

43. (D) Cones
Cones are specialized photoreceptor cells densely concentrated in the central retina, particularly within the fovea centralis region. They operate efficiently under bright light conditions and contain photopigments sensitive to distinct red, green, and blue light wavelengths, enabling full colour perception and sharp details in human visual function.

44. (B) Aqueous humor
Aqueous humor is a clear, watery fluid that fills the anterior chamber located between the cornea and the crystalline lens. Produced continuously by the ciliary body, it maintains intraocular pressure, delivers essential nutrients to avascular ocular tissues, and assists in maintaining the proper spherical contour of the front eye segment.

45. (A) II, III, IV, I
Image formation in a camera follows a precise sequential optical pathway. First, ambient light

ANSWERS

1. (B) Lens
A lens is a transparent optical medium bounded by two curved surfaces or by one spherical surface and one plane surface. Lenses function by refracting light rays passing through them, causing the rays to either converge or diverge depending on their curvature. They are essential optical components used in various imaging devices and visual aids.

2. (A) Thicker in the middle and thinner at the edges
A standard convex lens possesses a curved physical structure that is thicker at its central region and tapers down to become thinner along its outer edges. This specific geometric shape allows the lens to refract incoming parallel light rays inward toward a common focal point, earning it the functional designation of a converging lens.

3. (C) Virtual, erect, and diminished
A concave lens consistently causes light rays passing through it to diverge outwards. As a result, when light rays originating from a real object pass through a concave lens, they never physically intersect on the opposite side. Instead, their virtual extensions meet on the same side, forming a virtual, erect, and diminished image.

4. (D) $1/f = 1/v - 1/u$
The standard lens formula expresses the mathematical relation between focal length, object distance, and image distance for spherical lenses. Following standard Cartesian sign conventions, this relation is given by the formula where reciprocal of focal length equals reciprocal of image distance minus reciprocal of object distance. This is concisely represented as $1/f = 1/v - 1/u$.

5. (C) Dioptre
The power of a lens measures its degree of convergence or divergence of light rays and is defined as the reciprocal of focal length in meters. In the International System of Units, power is measured in dioptres. One dioptre equals the refractive power of a lens with a focal length of one meter.

6. (B) Converging lens
A convex lens is referred to as a converging lens because it bends incoming parallel rays of light inward, causing them to intersect at a focal point behind the lens. This refractive behavior occurs because the central portion of the convex lens is thicker than its edges, bending rays towards the central principal axis.

7. (D) Retina
The retina is the light-sensitive neural tissue layer lining the back inner surface of the human eye. It acts as an organic screen where inverted real images are focused by the eye lens system. Photoreceptor cells inside the retina capture incoming light and convert it into electrical signals sent to the brain.

8. (A) P-4, Q-3, R-2, S-1
The human eye components perform specific physiological functions. The iris regulates the pupil size, which in turn controls the amount of light entering the interior of the eye. The retina serves as a sensitive screen for image formation, while ciliary muscles alter the curvature of the crystalline lens to adjust its focal length.

9. (C) 25 cm to infinity
The visual range of a healthy human eye spans from its near point to its far point. The near point, or least distance of distinct vision, is approximately twenty-five centimeters for normal young adults. The far point extends to infinity, enabling clear focus on extremely distant objects without visual strain.

10. (A) Accommodation
Accommodation refers to the physiological process by which the human eye lens adjusts its focal length to maintain a clear focus on objects at varying distances. Ciliary muscles contract or relax to change the curvature and thickness of the flexible crystalline lens, ensuring that incoming light converges precisely on the retina.

11. (B) 25 cm
The near point, also known as the least distance of distinct vision, represents the closest distance at which an object can be clearly viewed by an

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pressure against the ocular walls, maintaining the structural integrity and spherical shape of the human eye.

57. (C) Pupil
The pupil is the central circular aperture located within the dark diaphragm of the iris. It functions as an adjustable opening that regulates light entry into the interior eye structure. Surrounding sphincter and dilator muscles within the iris contract or relax to alter pupil diameter based on ambient light intensity.

58. (D) I, II and III
Contact lenses are effective thin optical devices placed directly on the corneal surface to correct refractive errors as an alternative to glasses. Modern soft contact lenses are fabricated from flexible, hydrophilic hydrogel or silicone hydrogel polymers that absorb water, ensuring oxygen permeability and comfort during continuous wear on the eye.

59. (D) Retention of an image on the retina for about 1/16th of a second after the object is removed
Persistence of vision refers to the neurological phenomenon where a visual image remains recorded on the retina for approximately one-sixteenth of a second after the original stimulus disappears. This brief temporal delay allows the brain to blend sequentially displayed static images into the perception of continuous motion in cinematography.

60. (A) I, II, III, IV
Optical power is inversely proportional to focal length, meaning a lens with higher power possesses a shorter focal length. Calculating focal lengths for powers of plus ten, plus five, plus two, and plus zero point five dioptres yields values of ten, twenty, fifty, and two hundred centimeters, confirming increasing order.

61. (C) Real, inverted, and of the exact same size as the object
Placing an object at the center of curvature, designated as two F, of a convex lens results in symmetrical light refraction. The lens focuses the rays on the opposite side precisely at its second center of curvature, producing a real, inverted image possessing identical dimensions to the original object.

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62. (D) Corneal infections and ulcers
Neglecting strict hygiene when handling contact lenses promotes the accumulation of pathogenic bacteria, fungi, and dangerous microorganisms like Acanthamoeba on the lens surface. Placing contaminated lenses directly on the eye can breach the protective corneal epithelium, resulting in severe corneal infections, keratitis, and potentially vision-threatening microbial corneal ulcers.

63. (A) -2.0 D, Concave lens
A lens with a negative focal length is inherently a concave lens because it diverges incoming light rays. Converting fifty centimeters to meters gives negative zero point five meters. Calculating optical power as the reciprocal of focal length yields negative two dioptres, establishing both power value and lens type.

64. (B) It controls the amount of light entering the optical instrument.
An aperture is an adjustable circular opening integrated within optical instruments such as cameras and optical telescopes. By varying its physical diameter, the aperture regulates the total volume of light passing through the optical system, ensuring optimal image exposure, sharpness, and depth of field during visual capture or observation.

65. (A) P-4, Q-3, R-1, S-2
Ocular parameters correspond to established values in physiological optics. The far point of a normal eye is infinity, whereas its near point is twenty-five centimeters. Image retention on the retina lasts one-sixteenth of a second due to persistence of vision, and a flat glass plate exhibits zero dioptres of power.

66. (A) Outer surface of the cornea
The vast majority of light refraction in the human eye occurs at the outer boundary of the cornea. Because the refractive index difference between air and the corneal surface is larger than between internal eye fluids and the crystalline lens, the cornea performs roughly seventy percent of total ocular focusing.

67. (C) Real and inverted
Linear magnification is defined as the ratio of image height to object height. Under standard optical sign conventions, object height is always positive. Therefore, a negative magnification

advantages over traditional inorganic glass, including exceptional impact resistance, reduced weight, enhanced safety against shattering, and superior optical clarity, making them the standard choice for daily corrective eyewear.

23. (D) Cornea
Contact lenses are ultra-thin optical devices designed to rest directly upon the tear film covering the outer surface of the cornea. Because the cornea provides the primary refractive surface of the eye, positioning corrective lenses directly against it corrects refractive errors cleanly while providing a wide, unobstructed visual field.

24. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Hypermetropia is a refractive defect where light rays from nearby objects focus behind the retina due to inadequate convergence by the eye lens. Applying a convex lens adds positive converging power to incoming rays, bending them inward so they meet directly on the retinal surface, rendering both statements accurate and logically connected.

25. (C) High-power convex lens
A simple microscope is an optical magnifying instrument constructed using a single convex lens of short focal length, which corresponds to high optical power. When an object is placed within its focal length, the lens produces a virtual, upright, and significantly magnified image that can be viewed clearly by the human eye.

26. (A) Convex lens of large focal length and large aperture
An astronomical telescope uses a convex lens as its objective to gather light from distant astronomical bodies. This objective lens requires a large focal length to produce a prominent intermediate image and a wide aperture to collect a substantial amount of faint light, maximizing both brightness and image resolution for observation.

27. (D) Eye
A photographic camera operates on optical principles directly analogous to the human eye structure. Both systems utilize a converging lens mechanism to focus incoming light rays, a diaphragm or iris to adjust light exposure, and a light-sensitive surface, such as electronic sensors or the retina, to record inverted real images.

28. (B) Photographic film
In both optical designs, light rays pass through a focusing lens to form an inverted real image on an internal light-sensitive medium. In a traditional camera, photographic film or a digital sensor captures the image, functioning analogously to the biological retina, which contains photoreceptor cells to convert optical images into nerve signals.

29. (C) Virtual, erect, and magnified
A magnifying glass consists of a single convex lens. When an object is positioned between the optical centre and the principal focus of the lens, light rays refract and diverge. Tracing these diverging rays backwards reveals their point of intersection on the same side, creating a virtual, upright, and enlarged image.

30. (A) Cornea → Pupil → Lens → Retina
Light entering the human eye first passes through the transparent outer layer known as the cornea, where primary refraction occurs. It then travels through the central opening called the pupil, enters the adjustable crystalline lens to undergo fine focusing, and finally projects onto the light-sensitive retina at the back of the eye.

31. (B) +50 cm
The power of a lens is defined as the reciprocal of its focal length expressed in meters. Given a power of positive two dioptres, calculating the reciprocal yields a focal length of positive zero point five meters. Converting this metric value into centimeters results in a focal length of positive fifty centimeters.

32. (B) Surgical removal of the clouded lens and intraocular lens implantation
Cataracts involve irreversible clouding of the natural crystalline eye lens, which cannot be cured using drops or spectacle corrective lenses. The definitive standard treatment requires surgical removal of the opaque natural lens, typically via phacoemulsification, followed by the permanent implantation of a transparent synthetic intraocular lens to restore clear vision.

33. (B) LASIK
LASIK, which stands for Laser-Assisted in Situ Keratomileusis, is a widely performed refractive surgical procedure. It utilizes a specialized cool ultraviolet laser beam to precisely reshape the underlying corneal stroma, altering its curvature

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Consequently, the individual cannot focus comfortably at the normal near point distance of twenty-five centimeters, causing their effective near point to recede further away from the eye.

79. (A) Rods
Rods are specialized rod-shaped photoreceptor cells distributed densely across the peripheral regions of the human retina. Highly sensitive to light due to the photopigment rhodopsin, rods operate effectively under low illumination conditions, providing scotopic night vision and detection of light movement, though they cannot distinguish between different light colors.

80. (A) P-3, Q-1, R-2, S-4
Spectacle components fulfill specific functional optical roles. In bifocals, the upper portion contains a concave lens for distant viewing, while the lower section features a convex reading lens. Polycarbonate material offers lightweight, impact-resistant lens construction, and polarized or tinted lenses filter glare caused by intense bright sunlight reflections.

81. (B) Only I and II
Astigmatism stems from irregular corneal curvature, causing focal variations along different meridians that blur lines oriented in specific directions. It is effectively corrected using cylindrical lenses to unify axial focus. Clouding of the eye lens describes cataracts rather than astigmatism, making only the first two statements factually correct.

82. (A) Dark choroid layer
The choroid is a highly vascular, heavily pigmented vascular layer located between the outer sclera and the inner retina. Rich in melanin pigments, the choroid absorbs stray light entering the eye, preventing internal light reflection and scattering within the eyeball, which ensures high image contrast and clarity on the retina.

83. (C) To capture subjects with varied fields of view and magnification
Photographers utilize lenses with differing focal lengths to control image magnification and field of view. Telephoto lenses have long focal lengths to narrow the field of view and magnify distant subjects, whereas wide-angle lenses possess short focal lengths to capture broad spatial scenes within a single image frame.

84. (D) Real, inverted, and diminished
The human eye system behaves as a converging lens system where light rays from an object pass through the cornea and crystalline lens. Because objects are located beyond the lens focus, light rays physically intersect on the retinal surface, producing an image that is real, inverted, and smaller than the object.

85. (A) P-2, Q-3, R-4, S-1
Convex lens ray optics dictate predictable image positions based on object placement. Objects at infinity form images at focus F, objects beyond 2F yield images between F and 2F, objects at 2F form images at 2F on the far side, and objects closer than F produce virtual images on the same side.

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86. (B) Colour blindness
Myopia, hypermetropia, and presbyopia are refractive errors caused by geometric or mechanical focusing limitations of the ocular lens system, all of which are readily corrected using optical lenses. In contrast, colour blindness is a genetic photoreceptor deficiency in retinal cone cells that cannot be corrected with standard optical prescription lenses.

87. (D) Concave
A concave lens causes light rays to diverge upon refraction, regardless of object distance. The backward rays intersect on the object side, forming a virtual, upright image that is smaller than the object. This property of producing reduced, erect virtual images at all distances is unique to diverging concave lenses.

88. (A) The near point (25 cm)
When using a convex lens as a simple magnifier, maximum angular magnification with clear comfortable focus occurs when the virtual image is formed at the eye's near point, standardly measured as twenty-five centimeters. Positioning the image at this distance allows the observer to view the finest details without excessive accommodation strain.

89. (C) Retina
The retina contains specialized photoreceptor cells, known as rods and cones, which contain light-sensitive photopigment molecules. When light strikes these photopigments, it triggers a cascade of biochemical reactions that convert optical light energy into electrical nerve impulses,

which travel along the optic nerve to the visual cortex of the brain.

90. (A) III, IV, II, I
Standard cataract surgery follows a precise clinical order. First, local anesthesia is administered to numb the patient's eye. Next, a small incision is made in the cornea. The clouded natural lens is then emulsified and removed, followed finally by the implantation of a clear artificial intraocular lens into the lens capsule.

91. (C) +2 D
When two thin lenses are placed in direct contact, their combined optical power is calculated by adding their individual power values algebraically. Adding a positive three dioptre convex lens power to a negative one dioptre concave lens power yields a net combined power of positive two dioptres for the lens system.

92. (B) Fovea centralis (Macula)
The fovea centralis is a small pitted region located at the center of the macula lutea on the retina. Lacking vascular interference and containing an extremely high density of cone photoreceptor cells, this area provides the highest visual acuity, resolving sharp central detail required for activities like reading and driving.

93. (C) Intraocular Lens
The medical acronym IOL stands for Intraocular Lens. It refers to a tiny, transparent synthetic optical lens surgically implanted inside the eye during cataract procedures to replace the natural crystalline lens that has become cloudy, restoring proper light focusing capability and clear visual acuity to the patient's ocular system.

94. (D) Astronomical telescope - Objective lens has large focal length and aperture
An astronomical telescope utilizes a primary objective convex lens featuring a large focal length and a wide aperture. The large aperture gathers maximum light from faint, distant celestial targets, while the long focal length creates a magnified intermediate real image, which is subsequently observed through an eyepiece lens assembly.

95. (A) P-2, Q-3, R-4, S-1
Standard optical concepts align with specific medical and physical definitions. The dioptre measures optical lens power, and the cornea represents transparent ocular tissue frequently donated for corneal transplants. LASIK denotes refractive laser eye surgery, whereas the Snellen chart serves as the standard tool for measuring visual acuity.

96. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Human binocular vision relies on two eyes positioned horizontally a short distance apart. Each eye views objects from a slightly different perspective, capturing two distinct images. The visual cortex processes and merges these disparate retinal images into a single three-dimensional perception, providing depth perception, validating both statements directly.

97. (B) Astigmatism
Astigmatism is a refractive defect resulting from an asymmetrical curvature of the corneal or lens surface. When the curvature along one vertical or horizontal plane is steeper than along another plane, light rays fail to focus to a single point, resulting in distorted or blurred visual image formation on the retina.

98. (A) Reading in dim light for long durations
Reading under inadequate or dim lighting conditions forces the ciliary muscles and pupil dilators to work excessively hard, causing eye strain, headaches, and fatigue. Maintaining healthy visual hygiene requires proper illumination, regular blinking while viewing screens, and keeping reading materials at a safe distance of at least twenty-five centimeters.

99. (C) Principal axis
The principal axis of a spherical lens is defined as the imaginary straight line passing perpendicularly through the centres of curvature of its two curved optical surfaces. This fundamental reference line also passes directly through the optical centre of the lens, serving as the baseline for optical ray diagrams and distance measurements.

100. (A) P-2, Q-1, R-4, S-3
Ocular conditions produce distinct clinical symptoms. Cataract causes cloudy or milky vision due to lens opacification, while myopia impairs distant vision clarity. Hypermetropia creates difficulty in focusing on near objects, and colour blindness manifests as an inability to distinguish between specific colours, notably red and green wavelengths.

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101. (B) 20
The magnifying power of an astronomical telescope in normal adjustment is calculated as the ratio of the focal length of the objective lens to the focal length of the eyepiece. Dividing one hundred centimeters by five centimeters yields a dimensionless magnification factor of twenty, representing the scale of angular magnification.

102. (B) Concave lens (Diverging)
An air bubble trapped inside a glass block acts as a spherical volume of lower refractive index surrounded by a medium of higher refractive index. When light rays pass from glass into air and back, they refract outward, causing the spherical air bubble to behave as a diverging concave lens.

103. (D) Hypermetropia
Presbyopia naturally develops in aging individuals due to reduced lens elasticity, impairing close-up visual focusing. Older adults frequently suffer from pre-existing hypermetropia or myopia alongside presbyopia. To correct both distance and close reading vision simultaneously, eye care professionals prescribe bifocal spectacles containing distinct upper and lower lens zones.

104. (A) Astigmatism
A spectacle prescription containing a cylindrical power component along with a specified axis angle indicates correction for astigmatism. Unlike spherical power which corrects myopia or hypermetropia uniformly, cylindrical power compensates for irregular corneal or crystalline lens curvature along a specific meridian to focus light evenly on the retina.

105. (A) Only I and II
The sclera forms the tough, fibrous white outer layer that protects internal ocular structures, while the underlying vascular choroid layer supplies blood, oxygen, and nutrients to the eye tissues. The cornea, however, is completely transparent to allow light transmission, making the third statement incorrect while the first two are accurate.

106. (B) Below the principal axis
In standard Cartesian coordinate systems for optics, the principal axis serves as the horizontal reference baseline. Object height measured vertically upward above the principal axis is defined as positive. Because real inverted images project downward below this principal axis, their image heights are assigned negative values in ray diagrams.

107. (D) Conjunctiva
The conjunctiva is a thin, clear, transparent mucous membrane that covers the anterior sclera of the eye and lines the inner surface of the eyelids. It functions to protect and lubricate the ocular surface by producing mucus and tears, preventing foreign particles and pathogens from damaging sensitive corneal tissue.

108. (B) Pupil
When transitioning from a brightly lit environment to a dark room, the pupil undergoes reflexive dilation. Controlled by radial muscles in the iris, the pupil expands its central diameter to allow more ambient light into the eye, gradually restoring visual sensitivity to see objects clearly under dim lighting conditions.

109. (C) Between the focus and the optical centre
A concave lens consistently diverges light rays regardless of object position. When an object is placed at the principal focus of a concave lens, the refracted divergent rays project backward to intersect on the same side, forming a virtual, upright, and diminished image situated between the principal focus and optical centre.

110. (A) I, II, III, IV
Convergence power of a convex lens is inversely proportional to its focal length, meaning shorter focal lengths yield higher optical power. Lenses with focal lengths of plus ten, twenty-five, fifty, and one hundred centimeters correspond to powers of plus ten, four, two, and one dioptres, establishing a decreasing power order.

111. (A) Dispersion
Dispersion is the physical phenomenon where polychromatic light, such as white light, splits into its constituent spectrum of colors upon passing through a transparent medium like a prism. This occurs because different wavelengths of light travel at different speeds through the medium, refracting by slightly different angles along their paths.

112. (B) So they can be made much thinner and lighter than standard glass
High refractive index materials bend light more efficiently than conventional optical glass or plastic. Consequently, lenses constructed

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correct sequence?
(A) 2, 4, 1, 3
(B) 1, 2, 4, 3
(C) 2, 1, 4, 3
(D) 4, 2, 1, 3

81. India's independent regional navigation satellite system is named:
(A) GLONASS
(B) NavIC
(C) Galileo
(D) QZSS

82. NavIC (Navigation with Indian Constellation) consists of a constellation of how many satellites?
(A) 4
(B) 7
(C) 12
(D) 24

83. The NavIC satellites are placed in which type of orbits?
(A) Geostationary and Geosynchronous
(B) Low Earth Orbits and Medium Earth Orbits
(C) Polar and Sun-Synchronous Polar Orbits
(D) Highly Elliptical Sun-Synchronous Orbits

84. The coverage area of NavIC includes the Indian landmass and extends approximately how far beyond India's borders?
(A) 500 km
(B) 1500 km
(C) 5000 km
(D) Global coverage

85. Consider the following statements regarding NavIC:
I. It is designed to provide accurate position information service to users in India.
II. It provides two types of services: Standard Positioning Service and Restricted Service.
III. It completely replaces the need for the American GPS system globally.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II and III

86. What is 'space debris'?
(A) Natural cosmic dust particles present in interplanetary space
(B) Small metallic asteroids that cross the orbital path of Earth
(C) Volatile ice and gas fragments originating from active comets
(D) Non-functional human-made space objects

87. The theoretical scenario where the density of space debris in LEO becomes high enough to cause a cascading series of collisions is known as the:
(A) Drake Equation model
(B) Kessler Syndrome
(C) Fermi Paradox theory
(D) Roche Limit threshold

88. ISRO initiated which project to track space debris and safeguard Indian space assets?
(A) Project BHUVAN
(B) Project SHAKTI
(C) Project NETRA
(D) Project VEDAS

89. The International Space Station (ISS) orbits the Earth in which orbital zone?
(A) Medium Earth Orbit (MEO)
(B) Geostationary Orbit (GEO)
(C) Highly Elliptical Orbit (HEO)
(D) Low Earth Orbit (LEO)

90. Match List I with List II:
List I: Space Agency
P. NASA
Q. ESA
R. JAXA
S. Roscosmos
List II: Country/Region
1. Europe
2. Japan
3. Russia
4. USA
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

91. The International Space Station (ISS) serves primarily as a:
(A) Strategic orbital military weapons testing platform
(B) Microgravity and space research laboratory
(C) Telecommunication relay hub for deep space exploration missions
(D) Commercial orbital tourism hotel for private individuals

92. Approximately how long does the International Space Station take to complete one full orbit around the Earth?

CHAPTER 08

Space Technology and India's Space Programme

1. Which imaginary line is internationally recognized as the boundary between Earth's atmosphere and outer space?
(A) Armstrong line
(B) Kármán line
(C) Tropopause
(D) Magnetopause

2. What is the minimum velocity required for a spacecraft to permanently escape Earth's gravitational pull?
(A) 9.8 km/s
(B) 11.2 km/s
(C) 7.9 km/s
(D) 24.5 km/s

3. Who is widely acknowledged as the founding father of the Indian Space Programme?
(A) Vikram Sarabhai
(B) Homi J. Bhabha
(C) A. P. J. Abdul Kalam
(D) Satish Dhawan

4. In space technology, what is the term used for the equipment or instruments carried by a satellite to perform its designated task?
(A) Booster
(B) Propellant
(C) Payload
(D) Fairing

5. Which of the following is a natural satellite of the Earth?
(A) Moon
(B) Aryabhata
(C) Sputnik
(D) INSAT

6. Which of the following best defines an artificial satellite?
(A) A naturally occurring celestial body orbiting a planet
(B) A piece of space rock entering Earth's atmosphere
(C) A star system located far outside our home galaxy
(D) A human-made object orbiting a celestial body

7. What was the name of the first artificial satellite launched into space by humanity?
(A) Explorer 1
(B) Sputnik 1
(C) Vanguard 1
(D) Vostok 1

8. Based on their altitude, Low Earth Orbit (LEO) satellites typically operate in which height range above Earth's surface?
(A) Below 160 km
(B) 160 km to 2000 km
(C) 10000 km to 20000 km
(D) Above 35000 km

9. Communication satellites are most commonly placed in which type of orbit to remain fixed relative to a point on Earth?
(A) Polar orbit
(B) Sun-synchronous orbit
(C) Low Earth orbit
(D) Geostationary orbit

10. Consider the following statements regarding communication satellites:
I. They receive signals from Earth, amplify them, and retransmit them back.
II. Transponders are the key components used for communication in these satellites.
III. They operate exclusively in the visible light spectrum.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II and III

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from high-index materials require less surface curvature and less material thickness to achieve high corrective powers, resulting in significantly thinner, lighter, and aesthetically pleasing spectacle lenses for strong refractive prescriptions.

113. (B) +2.0 D
To enable an individual with a near point of fifty centimeters to read comfortable at twenty-five centimeters, corrective reading lenses must form a virtual image of the page at fifty centimeters. Using the lens formula with object distance minus twenty-five and image distance minus fifty yields a required power of positive two dioptres.

114. (A) The reflection of camera flash off blood vessels in the retina
The red eye effect occurs during flash photography in dim light when the pupil dilates broadly. The intense burst of photographic light enters the wide pupil, illuminating the vascular choroid and retinal blood vessels at the back of the eye, reflecting a reddish glow directly back into the camera lens.

115. (A) P-1, Q-2, R-3, S-4
Animal visual adaptations correspond to specialized ecological niches. Owls possess rod-dominated retinas optimized for nocturnal vision, while eagles feature dense cone distributions for high-acuity daytime hunting. Houseflies rely on compound eyes providing a wide viewing field, and humans utilize binocular vision to achieve accurate three-dimensional spatial depth perception.

116. (D) Vitamin A
Vitamin A is an essential precursor for synthesizing rhodopsin, the light-absorbing photopigment present in retinal rod cells responsible for low-light vision. Deficiency in Vitamin A impairs rod function, leading to night blindness, and severe prolonged deficiency can cause xerophthalmia, corneal drying, and permanent blindness if left unmanaged medically.

117. (C) Ophthalmoscope
An ophthalmoscope is a specialized optical diagnostic instrument used by eye care medical professionals to inspect the interior fundus of the human eye. Equipped with a light source and built-in lenses, it allows direct visualization of the retina, optic disc, retinal blood vessels, and macula to diagnose ocular and systemic diseases.

118. (B) It cannot be captured on a screen as light rays only appear to diverge
A virtual image is formed when light rays refracted by a lens diverge and do not physically intersect at any real focal point. Because light rays do not actually converge, the image cannot be focused onto a physical projection screen, but can be seen when backward-projected light rays enter the eye.

119. (D) A shorter focal length and more power
A thicker convex lens possesses surfaces with greater spherical curvature compared to a thin convex lens made of the same refractive material. Increased surface curvature causes incoming parallel light rays to bend more sharply, bringing them to a focal point closer to the lens, thereby decreasing focal length and increasing power.

120. (A) Immediately flush eyes with abundant clean running water for several minutes
Accidental chemical contact with the eye constitutes an immediate emergency requiring rapid intervention. Immediate, continuous flushing with clean running water or sterile saline solution for at least fifteen minutes dilutes and washes away the chemical, minimizing corneal epithelial damage and preventing severe tissue burns before seeking urgent medical attention.

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(C) 35,786 km
(D) 384,400 km

22. Which characteristic distinguishes a polar orbit from an equatorial orbit?
(A) It travels strictly along the Earth's equator
(B) It always remains stationary relative to the Earth's surface
(C) It is located beyond the orbit of the Moon
(D) It passes above or nearly above both poles of the Earth

23. What is the orbital period of a satellite in a geostationary orbit?
(A) 90 minutes
(B) 12 hours
(C) 24 hours
(D) 365 days

24. A satellite orbiting at an altitude of 600-800 km and capturing high-resolution images of the entire Earth over several days is most likely in a:
(A) Geostationary orbit
(B) Lunar orbit
(C) Sun-synchronous polar orbit
(D) Geosynchronous transfer orbit

25. Select the correct sequence of orbits arranged in increasing order of their typical altitudes above Earth:
(A) LEO, MEO, GEO
(B) GEO, MEO, LEO
(C) MEO, LEO, GEO
(D) LEO, GEO, MEO

26. What does the acronym GPS stand for?
(A) Global Positioning System
(B) General Positioning Satellite
(C) Global Pointing System
(D) Geospatial Positioning Satellite

27. What is the minimum number of GPS satellites required to determine a precise 3D position (latitude, longitude, and altitude) on Earth?
(A) 2
(B) 3
(C) 4
(D) 6

28. The Global Positioning System (GPS) is owned and operated by the government of which country?
(A) Russian Federation
(B) United States
(C) People's Republic of China
(D) French Republic

29. Which principle is primarily used by GPS receivers to calculate their exact location?
(A) Trilateration
(B) Magnetic resonance
(C) Quantum entanglement
(D) Doppler effect

30. Match List I with List II:
List I: Global Navigation System
P. GPS
Q. GLONASS
R. Galileo
S. BeiDou
List II: Country/Region
1. Russia
2. China
3. USA
4. European Union
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

31. In which year was the Indian Space Research Organisation (ISRO) established?
(A) 1958
(B) 1969
(C) 1975
(D) 1982

32. Where is the headquarters of the Indian Space Research Organisation (ISRO) located?
(A) New Delhi
(B) Hyderabad
(C) Bengaluru
(D) Thiruvananthapuram

33. Under which department of the Government of India does ISRO function?
(A) Department of Science and Technology
(B) Department of Space
(C) Department of Atomic Energy
(D) Ministry of Defence

34. What was the name of India's first indigenously built artificial satellite?
(A) Bhaskara
(B) Rohini
(C) INSAT-1A
(D) Aryabhata

35. Consider the following statements regarding India's first satellite:

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I. It was named Aryabhata after the famous ancient Indian astronomer.
II. It was launched in the year 1975.
III. It was launched using an American launch vehicle.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II and III

36. Which country provided the launch vehicle (Kosmos-3M) for India's first satellite, Aryabhata?
(A) USA
(B) France
(C) Soviet Union
(D) United Kingdom

37. Which of the following was one of the primary scientific objectives of the Aryabhata satellite?
(A) X-ray astronomy and solar physics
(B) Nationwide telecommunication broadcasting
(C) High-resolution lunar surface mapping
(D) High-altitude military spy reconnaissance

38. What does the acronym PSLV stand for in India's space programme?
(A) Polar Space Launch Vehicle
(B) Primary Satellite Launch Vehicle
(C) Public Space Launch Vehicle
(D) Polar Satellite Launch Vehicle

39. Which was the first experimental satellite launch vehicle developed by India in the 1980s?
(A) ASLV
(B) SLV-3
(C) PSLV
(D) GSLV

40. Arrange the following Indian launch vehicles in the correct chronological order of their first successful operational development:
1. GSLV
2. SLV-3
3. PSLV
4. ASLV
Which of the options given below represents the correct sequence?
(A) 2, 4, 3, 1
(B) 2, 3, 4, 1
(C) 4, 2, 3, 1
(D) 3, 2, 1, 4

41. How many stages does the standard Polar Satellite Launch Vehicle (PSLV) have?
(A) Two stages
(B) Three stages
(C) Four stages
(D) Five stages

42. What is the sequence of propellants used in the four stages of the PSLV?
(A) Liquid, Liquid, Solid, Solid
(B) Solid, Liquid, Solid, Liquid
(C) Solid, Solid, Liquid, Liquid
(D) Liquid, Solid, Liquid, Solid

43. Which Indian launch vehicle is famously known as the 'Workhorse of ISRO' due to its high reliability and success rate?
(A) SLV
(B) PSLV
(C) ASLV
(D) SSLV

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44. The historic Chandrayaan-1 and Mangalyaan missions were launched using which vehicle?
(A) GSLV Mk II
(B) PSLV
(C) LVM_3
(D) SLV-3

45. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Geosynchronous Satellite Launch Vehicle (GSLV) can lift heavier payloads than the PSLV.
Reason (R): GSLV utilizes a high-efficiency cryogenic upper stage that provides greater thrust.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

46. What does GSLV stand for?
(A) Global Space Station Launch Vehicle
(B) Geostationary Spacecraft Heavy Launch Vehicle
(C) Geosynchronous Satellite Launch Vehicle

(D) General Satellite Transport Launch Vehicle

47. The cryogenic upper stage of a GSLV rocket uses which of the following as propellants?
(A) Solid HTPB fuel and liquid N_2O_4 oxidizer
(B) Refined kerosene fuel and liquid oxygen
(C) Unsymmetrical hydrazine and nitric acid
(D) Liquid hydrogen and liquid oxygen

48. Why is the cryogenic engine technology considered highly complex?
(A) It functions exclusively in the vacuum outside Earth's atmosphere.
(B) It uses highly radioactive nuclear fuel requiring heavy shielding.
(C) It requires propellants stored at extremely low temperatures.
(D) It relies on continuous solar panel energy to ignite the fuel.

49. In which year was India's first lunar mission, Chandrayaan-1, launched?
(A) 2004
(B) 2008
(C) 2013
(D) 2019

50. Select the correct chronological order of the launches of ISRO's Chandrayaan missions:
(A) Chandrayaan-2, Chandrayaan-1, Chandrayaan-3
(B) Chandrayaan-1, Chandrayaan-2, Chandrayaan-3
(C) Chandrayaan-1, Chandrayaan-3, Chandrayaan-2
(D) Chandrayaan-3, Chandrayaan-1, Chandrayaan-2

51. Which major scientific discovery is attributed to India's Chandrayaan-1 mission?
(A) Confirmation of water molecules on the Moon
(B) Discovery of vast gold and platinum deposits on the Moon
(C) Discovery of active microbial life forms in lunar soil
(D) Direct evidence of active volcanic eruptions on the Moon

52. Chandrayaan-3 successfully achieved a soft landing near which region of the Moon?
(A) Lunar Equator
(B) Lunar North Pole
(C) Lunar South Pole
(D) Sea of Tranquility

53. The Mars Orbiter Mission (MOM), India's first interplanetary mission, is popularly known as:
(A) Mangalyaan
(B) Gaganyaan
(C) Shukrayaan
(D) Aditya

54. India became the first country in the world to achieve Mars orbit insertion in its:
(A) First attempt
(B) Second attempt
(C) Third attempt
(D) Fourth attempt

55. Match List I with List II:
List I: ISRO Mission
P. Chandrayaan
Q. Mangalyaan
R. Aditya-L_1
S. Shukrayaan (proposed)
List II: Target Celestial Body
1. Sun
2. Moon
3. Venus
4. Mars
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-2, R-1, S-3

56. What was the main objective of the Mars Exospheric Neutral Composition Analyser (MENCA) payload on Mangalyaan?
(A) To systematically map the topographically complex surface of Mars
(B) To drill deep into the Martian soil to detect subsurface ice
(C) To analyze neutral species in the Martian upper atmosphere
(D) To capture high-resolution optical images of the Martian moons

57. What is the primary objective of India's Gaganyaan mission?
(A) To collect and bring pristine soil samples back from the Moon
(B) To successfully deploy an autonomous robotic rover on Mars
(C) To construct a permanently inhabited space station on the Moon
(D) To send a human spaceflight mission to Low Earth Orbit

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11. Which frequency bands are primarily used by communication satellites for Direct-to-Home (DTH) television broadcasting?
(A) AM and FM bands
(B) Ku and C bands
(C) Ultraviolet bands
(D) X-ray bands

12. A device on a communication satellite that receives an uplink signal, changes its frequency, and transmits it as a downlink signal is called a:
(A) Gyroscope
(B) Transponder
(C) Solar panel
(D) Thruster

13. What is the primary function of a weather satellite?
(A) To observe atmospheric conditions and climate
(B) To track and monitor global financial transactions
(C) To provide high-speed internet connectivity to rural areas
(D) To explore and map the geographical surface of Mars

14. Which of the following is an Indian meteorological satellite specifically dedicated to weather forecasting?
(A) Cartosat-2
(B) GSAT-7
(C) Kalpana-1
(D) AstroSat

15. Match List I with List II:
List I: Satellite Type
P. Communication Satellite
Q. Earth Observation Satellite
R. Navigation Satellite
S. Astronomical Satellite
List II: Primary Application
1. GPS / Location tracking
2. DTH and Telephony
3. Deep space observation
4. Resource mapping
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-4, S-3

16. Weather satellites often use radiometers to capture images in which two primary spectrums?
(A) X-ray and Gamma-ray
(B) Radio and Microwave
(C) Visible and Infrared
(D) Ultraviolet and X-ray

17. The process of gathering information about Earth's surface from a distance using satellites is known as:
(A) Telecommunication
(B) Remote Sensing
(C) Geolocation
(D) Astrophotography

18. Which type of remote sensing satellite carries its own source of illumination (e.g., radar) to scan the Earth?
(A) Passive remote sensing satellite
(B) Optical remote sensing satellite
(C) Geostationary satellite
(D) Active remote sensing satellite

19. In the context of Rajasthan, remote sensing satellites are most highly utilized for which of the following?
(A) Monitoring desertification and groundwater
(B) Tracking moving icebergs across the open ocean
(C) Managing dense tropical rainforests and biodiversity
(D) Exploring deep-sea hydrothermal vents and trenches

20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Most remote sensing satellites are placed in Sun-synchronous polar orbits.
Reason (R): A Sun-synchronous orbit ensures that the satellite passes over any given point of the planet's surface at the same local solar time.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

21. What is the approximate altitude of a geostationary orbit above the Earth's equator?
(A) 400 km
(B) 20,200 km

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Assertion (A): IRS satellites provide continuous and consistent imagery of the Earth's surface.
Reason (R): They are placed in Geostationary orbits that remain fixed over one spot.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

71. The IRS satellite data is widely used in India for which of the following activities?
(A) Transmitting direct-to-home DTH television signals
(B) Forest mapping and crop estimation
(C) Navigation and guidance for commercial aircraft flights
(D) High-speed broadband internet services to rural areas

72. Which was the first operational Indian Remote Sensing satellite launched in 1988?
(A) Cartosat-1
(B) Resourcesat-1
(C) IRS-1A
(D) RISAT-1

73. Telecommunication networks heavily rely on satellites to link remote areas. Which frequency band is NOT typically used by telecom satellites?
(A) C band
(B) Ku band
(C) Ka band
(D) Gamma band

74. Very Small Aperture Terminal (VSAT) technology, commonly used for banking networks and rural communication, depends on which type of satellites?
(A) Communication satellites
(B) Navigation satellites
(C) Earth observation satellites
(D) Spy satellites

75. Match List I with List II:
List I: Satellite Series
P. Cartosat
Q. INSAT-3D
R. GSAT
S. NavIC
List II: Primary Purpose
1. Regional Navigation
2. High-resolution mapping
3. Telecommunication
4. Meteorology
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-1, R-2, S-4

76. Mobile telephony and satellite radio in remote terrain function by reflecting signals off which specific component of a communication satellite?
(A) Solar arrays
(B) Transponders
(C) Optical cameras
(D) Reaction wheels

77. How is space technology primarily applied in the field of agriculture?
(A) Assessing crop health and acreage using remote sensing
(B) Direct genetic modification of agricultural crop seeds from space orbit
(C) Delivering physical chemical fertilizers using controlled atmospheric drops
(D) Utilizing high-powered orbital geostationary lasers to heat agricultural soil

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78. In India, satellite data is extensively used to calculate the NDVI for agricultural drought assessment. What does NDVI stand for?
(A) National Drought Variance Assessment Indicator
(B) Natural Disaster Valuation and Risk Index
(C) Normalized Difference Vegetation Index
(D) Nominal Distance Vegetation Analysis Index

79. Satellites aid disaster management by predicting extreme weather events. Which Indian satellite series provides crucial data for tracking cyclones?
(A) RISAT
(B) AstroSat
(C) IRNSS
(D) INSAT

80. Arrange the following steps of satellite-based disaster management in their logical sequence:
1. Data Analysis and Damage Assessment
2. Acquisition of Satellite Imagery
3. Relief and Rescue Operations
4. Dissemination of Warnings
Which of the options given below represents the

58. Which heavy-lift launch vehicle is designated to launch the Gaganyaan crew module?
(A) LVM_3 (GSLV Mk III)
(B) PSLV-XL (Polar Satellite Launch Vehicle)
(C) SSLV (Small Satellite Launch Vehicle)
(D) SLV-3 (Satellite Launch Vehicle 3)

59. Who or what is 'Vyommitra' in the context of the Gaganyaan mission?
(A) The designated chief commander of the primary human crew
(B) A half-humanoid robot for uncrewed test missions
(C) The specialized primary launch pad located at Sriharikota
(D) The naval recovery vessel operated by the Indian Navy

60. Consider the following statements regarding the Gaganyaan mission:
I. It aims to demonstrate human spaceflight capability.
II. The crew will be placed in a Geostationary orbit at 36,000 km.
III. The crew module will safely return to Earth by splashing down in Indian waters.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only I and III
(C) Only II and III
(D) I, II and III

61. The Satish Dhawan Space Centre (SDSC), India's primary spaceport, is located in:
(A) Sriharikota
(B) Thumba
(C) Hassan
(D) Mahendragiri

62. In which Indian state is the Sriharikota launch centre situated?
(A) Tamil Nadu
(B) Kerala
(C) Andhra Pradesh
(D) Odisha

63. Why is Sriharikota considered an ideal location for launching satellites?
(A) It is situated at a very high altitude peak to minimize atmospheric drag.
(B) It is hidden deep within a dense forest to secure classified satellites.
(C) It experiences localized reduced gravity caused by a unique magnetic anomaly.
(D) It is near the equator with an eastern sea coast for safe launches.

64. Sriharikota is a spindle-shaped barrier island that separates the Bay of Bengal from which famous lake?
(A) Chilika Lake
(B) Vembanad Lake
(C) Pulicat Lake
(D) Sambhar Lake

65. What does INSAT stand for in the context of India's space programme?
(A) Indian Navigation Satellite
(B) Indian National Satellite System
(C) International Space and Aeronautics Technology
(D) Integrated Satellite Application Technology

66. The INSAT series of satellites are primarily deployed for which of the following purposes?
(A) Defense military reconnaissance and continuous border surveillance
(B) Deep space planetary exploration and astronomical observations
(C) High-precision agriculture and detailed soil moisture mapping
(D) Telecommunications, broadcasting, and meteorology

67. The GSAT series of satellites (e.g., GSAT-30, GSAT-31) launched by ISRO fundamentally belong to which category?
(A) Communication satellites
(B) Remote Sensing satellites
(C) Navigation satellites
(D) Weather observation satellites

68. The INSAT/GSAT satellites are predominantly placed in which type of orbit?
(A) Sun-synchronous orbit
(B) Low Earth Orbit
(C) Geostationary orbit
(D) Medium Earth Orbit

69. The acronym IRS in India's space programme stands for:
(A) Indian Remote Sensing
(B) Indian Radio System
(C) Integrated Rocket Stage
(D) International Radar Satellite

70. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

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(A) 24 hours
(B) 12 hours
(C) 90 minutes
(D) 27 days

93. In 2017, ISRO set a world record (at that time) by launching how many satellites in a single flight on PSLV-$C_3$7?
(A) 34
(B) 104
(C) 143
(D) 201

94. Who was the first Indian citizen to travel into space?
(A) Kalpana Chawla
(B) Sunita Williams
(C) Rakesh Sharma
(D) Ravish Malhotra

95. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): ISRO has achieved significant commercial success in the global space market.
Reason (R): The PSLV has a proven track record of launching foreign satellites cost-effectively and reliably.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

96. What is the name of India's first privately developed launch vehicle, which successfully completed a sub-orbital flight in 2022?
(A) Agnikul-1
(B) Kalam-V
(C) Vikram-S
(D) Dhruv-1

97. The GSAT-7 satellite, also known as Rukmini, is dedicated primarily to serving the needs of which organization?
(A) Indian Army
(B) Indian Navy
(C) Indian Air Force
(D) Border Security Force

98. EMISAT, launched by ISRO in 2019, is an advanced satellite designed primarily for:
(A) Detecting underground water reserves and aquifer resources
(B) Broadcasting high-definition nationwide educational channels
(C) Monitoring global sea surface temperatures and ocean currents
(D) Electromagnetic intelligence and radar surveillance

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99. Which of the following is a key application of space technology in the defence sector?
(A) Encrypted communication and border surveillance
(B) Generating nuclear power propulsion for naval submarines
(C) Developing advanced biological and chemical weapons systems
(D) Providing free commercial high-speed internet to soldiers

100. In 2019, India successfully tested an Anti-Satellite (ASAT) weapon under which mission?
(A) Mission Surya
(B) Mission Vayu
(C) Mission Shakti
(D) Mission Raksha

101. GSAT-3, launched in 2004, is famously known as:
(A) EDUSAT
(B) METSAT
(C) KALPANA
(D) HAMSAT

102. EDUSAT was exclusively designed to support which sector in India?
(A) Advanced medical research and healthcare infrastructure
(B) Commercial e-commerce and digital banking networks
(C) Precision agricultural forecasting and crop planning
(D) Distance education and virtual learning

103. How does space technology facilitate 'Telemedicine' in remote areas?
(A) By physically transporting specialized doctors via high-speed orbital rockets
(B) By providing satellite connectivity for remote medical consultations
(C) By sending fully automated robotic medical surgeons directly from space

and gamma radiation, and analyzing upper atmospheric parameters in Earth's ionosphere, laying the groundwork for future advanced space-based scientific exploration projects.

38. (D) Polar Satellite Launch Vehicle
PSLV stands for Polar Satellite Launch Vehicle, an expandable medium-lift launch system engineered by the Indian Space Research Organisation. Designed initially to launch Indian Remote Sensing satellites into Sun-synchronous polar orbits, it has evolved into a versatile launcher capable of delivering various payloads into diverse orbits, including geostationary transfer and lunar trajectories.

39. (B) SLV-3
Satellite Launch Vehicle 3 (SLV-3) was India's first experimental four-stage solid-propellant satellite launch system. Headed by A.P.J. Abdul Kalam as project director, SLV-3 achieved its first success on July 18, 1980, placing the Rohini RS-1 satellite into orbit, establishing India as the sixth nation with indigenous orbital launch capability.

40. (A) 2, 4, 3, 1
India's launch vehicle technology developed progressively over decades. The experimental SLV-3 achieved its initial orbital success in 1980, followed by the Augmented Satellite Launch Vehicle (ASLV) in 1987. The operational Polar Satellite Launch Vehicle (PSLV) debuted successfully in 1994, while the heavy-lift Geosynchronous Satellite Launch Vehicle (GSLV) reached operational status later in 2001.

41. (C) Four stages
The standard configuration of the Polar Satellite Launch Vehicle uses four distinct propulsion stages. It alternates between solid and liquid rocket propellants sequentially across its ascent trajectory. This four-stage architecture provides the precise velocity control and multi-payload separation capabilities required to launch remote sensing, scientific, and navigation satellites into specialized orbits.

42. (B) Solid, Liquid, Solid, Liquid
The Polar Satellite Launch Vehicle utilizes an alternating propellant combination across its four stages: solid, liquid, solid, liquid. The first stage uses solid HTPB fuel, the second employs Vikas liquid engine, the third relies on a high-thrust solid motor, and the fourth uses twin re-ignitable liquid engines for final payload injection.

43. (B) PSLV
The Polar Satellite Launch Vehicle earned the moniker 'Workhorse of ISRO' due to its exceptional reliability, high success rate, and operational flexibility. Over decades of service, PSLV has executed dozens of consecutive successful launches, delivering national remote sensing satellites, commercial foreign payloads, and landmark interplanetary missions into precise orbits.

44. (B) PSLV
India's inaugural lunar probe Chandrayaan-1 in 2008 and first interplanetary mission Mangalyaan in 2013 were both successfully launched using the Polar Satellite Launch Vehicle in its XL configuration. The additional strap-on motors provided the extra performance needed to place these spacecraft into highly elliptical orbits for their journeys.

45. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
The Geosynchronous Satellite Launch Vehicle is capable of lifting heavier payloads than the PSLV because it incorporates a high-efficiency cryogenic upper stage. Cryogenic engines utilize liquid hydrogen and liquid oxygen propellants, delivering significantly higher specific impulse and thrust compared to conventional solid or hypergolic liquid propellants, enabling heavy payload delivery to higher orbits.

46. (C) Geosynchronous Satellite Launch Vehicle
GSLV stands for Geosynchronous Satellite Launch Vehicle, a heavy-class launch system developed by the Indian Space Research Organisation. Engineered to deploy communication satellites into high-altitude Geosynchronous Transfer Orbits, GSLV incorporates cryogenic propulsion technology in its upper stage, enabling the transportation of heavier spacecraft into high-altitude orbits above Earth.

47. (D) Liquid hydrogen and liquid oxygen
Cryogenic rocket engines utilize liquid hydrogen as fuel and liquid oxygen as the oxidizer. These propellants must be stored at sub-zero cryogenic temperatures—hydrogen at minus 253 degrees Celsius and oxygen at minus 183 degrees Celsius.

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114. What is the name of the commercial arm of ISRO established in 2019 to handle the commercialization of space technologies?
(A) Antrix Corporation
(B) Videsh Sanchar Nigam Limited
(C) Space India Enterprise
(D) NewSpace India Limited

115. Match List I with List II:
List I: Organization/Agency
P. ISRO
Q. NSIL
R. IN-SPACe
S. IIRS
List II: Primary Role
1. Promotion and regulation of private space industry
2. Commercial arm of the Department of Space
3. Training and education in remote sensing
4. Research and development of space technology
(A) P-4, Q-2, R-1, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-3, R-4, S-1

116. What is the primary intended benefit of opening the Indian space sector to private players?
(A) To completely eliminate and permanently stop government funding for ISRO
(B) To sell sensitive defense military secrets to private foreign corporations
(C) To enhance India's global space economy share and foster innovation
(D) To restrict future satellite launches strictly to foreign territory soils

117. What is the main objective of ISRO's Aditya-L_1 mission?
(A) To observe and study the Sun continuously
(B) To study the atmosphere of Jupiter
(C) To perform the first human spacewalk by an Indian
(D) To map the polar ice caps of Mars

118. Match List I with List II:
List I: Future Space Mission
P. Gaganyaan
Q. Shukrayaan
R. NISAR
S. Mangalyaan-2
List II: Objective/Target
1. Venus orbiter
2. Second Mars mission
3. Human spaceflight
4. Joint Earth Observation with NASA
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

119. In the Aditya-L_1 mission, what does 'L_1' stand for?
(A) Lunar orbit trajectory 1
(B) Lagrange Point 1
(C) Launch vehicle platform 1
(D) Latitude coordinate 1

120. NISAR is a highly advanced synthetic aperture radar satellite being developed jointly by ISRO and which international space agency?
(A) European Space Agency (ESA)
(B) Roscosmos
(C) NASA
(D) JAXA

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mission establishes foundational technology for human space exploration, crew escape systems, environmental life support, and post-landing maritime recovery operations.

58. (A) LVM_3 (GSLV Mk III)
The Launch Vehicle Mark 3, formerly designated GSLV Mk III, is chosen for launching the Gaganyaan crew module. As India's heaviest rocket, LVM_3 provides the thrust required to inject the heavy crew module into Low Earth Orbit. It undergoes rigorous human-rating modifications to ensure safety and system redundancy standards for astronaut missions.

59. (B) A half-humanoid robot for uncrewed test missions
Vyommitra is a female-looking half-humanoid robot developed by ISRO to fly aboard uncrewed precursor test flights of the Gaganyaan programme. Equipped with artificial intelligence and sensor monitoring systems, Vyommitra simulates human functions, operates control panels, monitors atmospheric life support systems, and assesses cabin safety parameters prior to human spaceflights.

60. (B) Only I and III
Gaganyaan is designed to demonstrate human spaceflight capability by carrying a crew into Low Earth Orbit at an altitude of roughly 400 kilometers, not in a 36,000 km geostationary orbit. Following completion of mission tasks, the crew module will execute re-entry and safely splash down in Indian territorial waters.

61. (A) Sriharikota
The Satish Dhawan Space Centre, India's primary orbital spaceport, is located at Sriharikota. Named in honour of former ISRO Chairman Satish Dhawan, this facility houses launch complexes, rocket assembly buildings, fuel storage facilities, and tracking radar stations essential for carrying out orbital launches of PSLV, GSLV, and heavy-lift LVM_3 rockets.

62. (C) Andhra Pradesh
The Sriharikota spaceport is situated in the Tirupati district of Andhra Pradesh along the eastern coast of India. Positioned on an offshore island, its geographical setting provides strategic operational advantages for orbital launches, including an unpopulated downrange flight path over the Bay of Bengal for rocket staging and safety debris drop zones.

63. (D) It is near the equator with an eastern sea coast for safe launches.
Sriharikota offers ideal launch conditions due to its proximity to the equator, granting extra rotational velocity boost to eastward-launched rockets. Furthermore, its eastern coast location on the Bay of Bengal ensures spent rocket stages and launch debris drop safely into uninhabited ocean waters without posing hazards to populated land regions during ascent.

64. (C) Pulicat Lake
Sriharikota is a spindle-shaped barrier island situated between the Bay of Bengal to its east and Pulicat Lake to its west. Pulicat Lake is the second largest brackish water lagoon in India, and this natural coastal barrier geography isolates the spaceport facility while providing security and safety for rocket testing and launch operations.

65. (B) Indian National Satellite System
INSAT stands for Indian National Satellite System, a series of multipurpose geostationary satellites commissioned by India. Established as a joint venture across government departments, the INSAT constellation revolutionized domestic telecommunications, nationwide direct television broadcasting, radio networking, meteorological surveillance, and emergency search and rescue operations throughout the country.

66. (D) Telecommunications, broadcasting, and meteorology
The INSAT satellite network was established as a multipurpose operational system serving three major sectors: telecommunications, television and radio broadcasting, and meteorological observation. Positioned in geostationary orbit, these satellites carry communication transponders alongside meteorological imaging instruments to deliver continuous connectivity, weather monitoring, and warning services nationwide.

67. (A) Communication satellites
The GSAT series comprises indigenously developed communication satellites designed to meet India's growing demands for digital telecommunications, television distribution, VSAT connectivity, and broadband services.

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appearing stationary to ground observers. This fixed position enables continuous, uninterrupted telecommunications, direct broadcasting, and meteorological monitoring over specific regions.

10. (A) Only I and II
Communication satellites function primarily by intercepting electromagnetic signals transmitted from ground bases, amplifying these signals, and relaying them back down to ground antennas. They rely heavily on transponders operating within radio and microwave spectrum bands to facilitate long-distance communication. They do not operate exclusively in the visible spectrum, making high-frequency radio waves essential for reliable global connectivity.

11. (B) Ku and C bands
Direct-to-Home television services and satellite media distribution utilize the C band and Ku band microwave frequencies. The C band provides high reliability against rain fading over wide coverage zones, whereas the Ku band supports higher bandwidth and smaller receiving antennas suitable for direct residential reception. These microwave bands are optimal for transferring high-definition audio and video data efficiently.

12. (B) Transponder
A transponder is an electronic unit aboard a communication satellite designed to receive incoming uplink signals from ground stations. It amplifies the signal, shifts its frequency to prevent self-interference between transmitted and received waves, and retransmits it back to target receivers as a downlink signal, forming the core operational component of modern satellite telecommunication systems.

13. (A) To observe atmospheric conditions and climate
Weather satellites are environmental observation systems designed to continuously monitor Earth's atmosphere, weather patterns, cloud distributions, and climate systems. Equipped with advanced optical and thermal sensors, they track severe storms, measure temperature profiles, detect humidity levels, and forecast atmospheric changes. Their regular data updates enhance disaster warnings and improve accuracy in global meteorological predictions.

14. (C) Kalpana-1
Kalpana-1 was the first dedicated meteorological satellite launched by the Indian Space Research Organisation in 2002. Originally designated MetSat-1, it was renamed in memory of astronaut Kalpana Chawla. Placed in geostationary orbit, it carried Very High Resolution Radiometers to provide crucial data on cloud cover, atmospheric water vapor, rainfall estimates, and weather forecasting.

15. (A) P-2, Q-4, R-1, S-3
Satellites are classified according to their specialized functional roles in orbit. Communication satellites enable Direct-to-Home broadcasting and telephony. Earth observation satellites perform resource mapping and terrain analysis. Navigation systems facilitate Precise GPS positioning and location tracking. Astronomical observatories operate instruments above atmospheric distortion to conduct deep space exploration and study distant stars and galaxies.

16. (C) Visible and Infrared
Meteorological satellites rely on radiometers capturing radiation across the visible and infrared electromagnetic spectrums. Visible imagery records sunlight reflected off cloud tops and land surfaces during daylight hours. Infrared channels measure emitted thermal energy continuously, allowing meteorologists to assess surface temperature, atmospheric moisture, and cloud heights during both day and night, providing constant weather tracking capabilities.

17. (B) Remote Sensing
Remote sensing is the technique of gathering physical data about Earth's surface from elevated platforms without physical contact. Satellite sensors detect reflected solar radiation or emitted thermal energy across various wavelengths. This technology enables scientists to map natural resources, monitor agricultural health, track environmental changes, manage forestry, and assess surface conditions over expansive geographical areas efficiently.

18. (D) Active remote sensing satellite
Active remote sensing systems emit their own artificial electromagnetic radiation toward a target and measure the backscattered signal reflected to the sensor. Synthetic Aperture Radar is a primary example of this technology. Because

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(D) By sterilizing sensitive medical equipment using high-energy cosmic rays

104. Which ambitious Indian project utilizes satellite communications to provide broadband connectivity to Gram Panchayats lacking optical fibre?
(A) Digital India
(B) Swachh Bharat
(C) BharatNet
(D) Make in India

105. Match List I with List II:
List I: Application
P. Telemedicine
Q. Tele-education
R. Disaster Warning
S. Resource Mapping
List II: Relevance
1. Broadcasting cyclone alerts to coastal villages
2. Remote diagnosis of patients by specialists
3. Estimating mineral wealth and forest cover
4. Broadcasting interactive lectures to rural schools
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

106. The basic principle of rocket propulsion is based on which fundamental law of physics?
(A) Newton's First Law of Motion
(B) Newton's Second Law of Motion
(C) Newton's Third Law of Motion
(D) Law of Universal Gravitation

107. Rocket propulsion is a practical application of the conservation of:
(A) Angular momentum
(B) Linear momentum
(C) Mechanical energy
(D) Electric charge

108. The thrust produced by a rocket engine depends directly on the exhaust velocity of the gases and the:
(A) Ambient temperature of the surrounding outer space
(B) Mass flow rate of expelled gases
(C) Current altitude and velocity of the rocket vehicle
(D) Specific heat resistance material of the rocket nozzle

109. Why must launch vehicles carry an oxidizer along with the fuel?
(A) Because outer space lacks oxygen to support combustion
(B) To actively cool down the high-temperature combustion chamber
(C) To artificially increase the structural payload weight during launch
(D) To effectively protect sensitive satellite electronics from solar radiation

110. Consider the following statements regarding rocket propulsion:
I. Rockets generate thrust by expelling mass backward at high velocity.
II. A jet engine can operate in outer space because it carries its own oxidizer.
III. Multistage rockets shed empty fuel tanks to reduce mass and increase efficiency.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only I and III
(C) Only II and III
(D) I, II and III

111. Which of the following is an example of an economic utility derived directly from space research?
(A) Direct discovery and communication with intelligent alien life forms
(B) Theoretical development and commercialization of time-travel technology
(C) Industrial-scale mining of rare earth metals directly from the Sun
(D) Weather forecasting that reduces agricultural losses

112. Technologies originally developed for space missions that find commercial applications in everyday life (like water purifiers and memory foam) are called:
(A) Extraterrestrial assets
(B) Black box technologies
(C) Spinoff technologies
(D) Core payload tech

113. Which independent nodal agency was created by the Government of India to promote, regulate, and authorize private sector activities in space?
(A) NSIL
(B) IN-SPACe
(C) Antrix
(D) DRDO

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precise timing measurement necessary for spatial accuracy.

28. (B) United States
The Global Positioning System was established and is maintained by the United States government, operated specifically by the United States Space Force. Designed originally as a strategic military asset named NAVSTAR, its signal was subsequently made available worldwide for civilian usage, providing open position, velocity, and timing services to users around the world continuously.

29. (A) Trilateration
GPS receivers calculate location using trilateration, a mathematical technique that calculates absolute position by measuring relative distances from known points. The receiver measures the time taken for radio signals to travel from multiple satellite positions. Intersecting these calculated spherical ranges allows the receiver to isolate its exact latitude, longitude, and altitude on Earth's surface accurately.

30. (A) P-3, Q-1, R-4, S-2
Global navigation satellite constellations are deployed by various nations and regional groups for worldwide positioning. The United States operates the GPS network. The Russian Federation maintains the GLONASS constellation. The European Union developed and manages the Galileo system. China built and operates the BeiDou Navigation Satellite System to deliver independent global spatial positioning coverage.

31. (B) 1969
The Indian Space Research Organisation was formally founded on August 15, 1969, superseding the Indian National Committee for Space Research established earlier in 1962. Its establishment unified national space activities under a dedicated organizational structure, aiming to harness space technology for socio-economic development, resource mapping, communication, and scientific exploration across India.

32. (C) Bengaluru
The headquarters of the Indian Space Research Organisation is situated in Bengaluru, Karnataka. Known as Antariksh Bhavan, this central facility coordinates operations across various ISRO centers nationwide, directing overall mission planning, policy execution, satellite development projects, launch operations, and space application programs under the administrative framework of the Department of Space.

33. (B) Department of Space
The Indian Space Research Organisation operates directly under the Department of Space within the Government of India. Created in 1972 alongside the Space Commission, the Department of Space formulates national space policy and allocates executive management responsibilities to ISRO, ensuring systematic execution of satellite development, launch vehicle production, and space research infrastructure.

34. (D) Aryabhata
Aryabhata was India's pioneer artificial satellite, constructed indigenously by the Indian Space Research Organisation. Named after the distinguished fifth-century Indian astronomer and mathematician, the satellite was built to conduct scientific experiments in X-ray astronomy, aeronomy, and solar physics, marking India's entry into the space age as a satellite-building nation.

35. (A) Only I and II
Aryabhata was named after the ancient Indian astronomer and launched successfully in 1975. However, it was not launched using an American launch vehicle; rather, it was placed into orbit using a Soviet Kosmos-3M rocket from Kapustin Yar. This landmark mission demonstrated India's capability to design and fabricate operational scientific spacecraft.

36. (C) Soviet Union
The Soviet Union provided the launch vehicle support for India's inaugural satellite, Aryabhata. Launched on April 19, 1975, from the Kapustin Yar launch complex, the satellite was placed into Low Earth Orbit using a Soviet Kosmos-3M rocket under a collaborative bilateral agreement between the space organizations of both nations.

37. (A) X-ray astronomy and solar physics
The Aryabhata spacecraft was engineered as a scientific research platform carrying instruments for high-energy astrophysics. Its primary research goals encompassed investigating galactic X-ray emissions, measuring high-energy solar neutrons

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these satellites do not depend on ambient sunlight, they can capture high-resolution imagery through cloud cover, fog, and during total atmospheric darkness continuously.

19. (A) Monitoring desertification and groundwater
In arid regions like Rajasthan, remote sensing technology is critical for monitoring desertification processes, mapping sand dune dynamics, and assessing subterranean groundwater resources. Satellite observations facilitate precise tracking of vegetation degradation, soil moisture changes, surface water bodies, and land use patterns, providing land managers and policymakers with essential data for sustainable environmental and water management programs.

20. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
Remote sensing satellites are typically placed in Sun-synchronous polar orbits because this orbit precesses at the exact rate of Earth's solar orbit. Consequently, the satellite passes over any location at the exact same local solar time, ensuring consistent illumination angles and consistent shadow conditions, which are vital for reliable multi-temporal comparison of Earth imagery over time.

21. (C) 35,786 km
A geostationary orbit lies precisely along Earth's equatorial plane at an altitude of approximately 35,786 kilometers above sea level. At this specific distance, the orbital period perfectly matches Earth's sidereal rotation period. Consequently, satellites positioned here remain permanently overhead relative to a specific surface location, making it ideal for telecommunications, television transmission, and broad weather monitoring.

22. (D) It passes above or nearly above both poles of the Earth
A polar orbit features an inclination close to ninety degrees relative to the equator, carrying the satellite over or near both the North and South Poles during each orbit. As the Earth rotates beneath this fixed orbital plane, the satellite scans different longitudinal strips, allowing complete global surface coverage over successive orbits, unlike purely equatorial orbits.

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23. (C) 24 hours
The orbital period of a geostationary satellite is approximately 23 hours, 56 minutes, and 4 seconds, matching Earth's sidereal rotation day, commonly referred to as 24 hours. Because the satellite orbits in the direction of Earth's rotation at this synchronized rate, it maintains a fixed stationary appearance relative to any ground point along the equatorial belt.

24. (C) Sun-synchronous polar orbit
Satellites operating at altitudes between 600 and 800 kilometers in Sun-synchronous polar orbits provide global surface coverage under consistent solar lighting conditions. The polar inclination enables complete Earth coverage as the planet rotates below, while the Sun-synchronous geometry ensures identical sun angles during each pass, rendering this orbit optimal for high-resolution optical imaging and environmental monitoring.

25. (A) LEO, MEO, GEO
Earth orbits are categorized by their altitude above the planet's surface. Low Earth Orbit operates between 160 and 2,000 kilometers. Medium Earth Orbit spans from 2,000 kilometers up to roughly 35,786 kilometers, where navigation constellations reside. Geostationary Earth Orbit sits at approximately 35,786 kilometers. Arranging these zones by altitude yields the sequence of LEO, MEO, and GEO.

26. (A) Global Positioning System
GPS stands for Global Positioning System, a satellite-based radionavigation architecture that provides precise location, velocity, and timing information worldwide. Originally constructed for military applications, it now serves extensive civilian roles across aviation, maritime navigation, mobile location services, geospatial mapping, and global telecommunications infrastructure by transmitting continuous radio signals from an orbital constellation.

27. (C) 4
Calculating a precise three-dimensional position consisting of latitude, longitude, and altitude requires signals from at least four separate satellites. Three satellite distance measurements determine spatial coordinates through geometric trilateration. The fourth satellite signal resolves receiver clock bias against the satellite atomic clocks, ensuring accurate synchronization and

Combustion of this high-energy mixture yields high exhaust velocities and superior propulsion efficiency for heavy payload missions.

48. (C) It requires propellants stored at extremely low temperatures.
Cryogenic engine technology is technically challenging because it requires managing propellants at extreme cryogenic temperatures near absolute zero. Storing liquid hydrogen and liquid oxygen demands specialized thermal insulation, advanced metallurgy, specialized pumping systems, turbo-pumps, and complex ignition mechanisms to operate reliably in harsh launch conditions without propellant boil-off or structural failure.

49. (B) 2008
Chandrayaan-1, India's pioneer deep-space lunar orbiter, was launched on October 22, 2008, from Sriharikota. Operating in lunar orbit, it carried eleven scientific instruments to generate a three-dimensional atlas of the Moon and map surface mineralogical composition, achieving a major milestone in Indian space exploration and scientific research.

50. (B) Chandrayaan-1, Chandrayaan-2, Chandrayaan-3
India's lunar exploration programme progressed in numerical sequence over time. Chandrayaan-1 was launched in October 2008, establishing orbital presence. Chandrayaan-2 followed in July 2019, comprising an orbiter, lander, and rover. Chandrayaan-3 was launched in July 2023, successfully accomplishing a soft touchdown near the lunar south pole, reflecting progressive mission maturity.

51. (A) Confirmation of water molecules on the Moon
A historic discovery of the Chandrayaan-1 mission was the unambiguous confirmation of water molecules and hydroxyl radicals on the lunar surface. Utilizing payloads such as the Moon Mineralogy Mapper and the Impact Probe, the mission detected spectroscopic evidence of water molecules bound in polar lunar soil, reshaping understanding of lunar geological history.

52. (C) Lunar South Pole
Chandrayaan-3 achieved a historic landing on August 23, 2023, near the lunar south pole region at approximately 69 degrees south latitude. This region is of immense scientific interest due to permanently shadowed craters containing water ice deposits, making India the first nation to soft-land a spacecraft successfully near the Moon's south pole.

53. (A) Mangalyaan
The Mars Orbiter Mission, popularly named Mangalyaan, was India's inaugural interplanetary space endeavor launched by ISRO in November 2013. Designed to explore Martian surface features, morphology, mineralogy, and atmospheric composition, it successfully entered orbit around Mars in September 2014, establishing India as a leader in cost-effective interplanetary exploration capabilities.

54. (A) First attempt
India made space history by becoming the first country globally to achieve successful Mars orbit insertion on its initial attempt when Mangalyaan entered Martian orbit on September 24, 2014. Additionally, India was the fourth space agency worldwide to reach Mars, accomplishing this interplanetary feat at a fraction of standard international mission costs.

55. (A) P-2, Q-4, R-1, S-3
India's space program targets various celestial bodies across its space exploration roadmap. The Chandrayaan missions explore the Moon, while Mangalyaan investigates Mars. The Aditya-L_1 observatory is placed to observe solar dynamics continuously, and the proposed Shukrayaan mission aims to orbit and examine the thick atmosphere and surface conditions of Venus.

56. (C) To analyze neutral species in the Martian upper atmosphere
The Mars Exospheric Neutral Composition Analyser carried on the Mangalyaan spacecraft was designed to analyze the neutral composition of the Martian exosphere. It measured relative abundances of neutral gas species and their altitudinal variations, providing critical scientific insight into atmospheric escape processes and upper atmospheric dynamics on Mars.

57. (D) To send a human spaceflight mission to Low Earth Orbit
Project Gaganyaan aims to demonstrate human spaceflight capability by launching a crew into a 400-kilometer Low Earth Orbit for a multi-day mission and returning them safely to Earth. This

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ANSWERS

1. (B) Kármán line
The Kármán line represents the convention for defining the boundary between Earth's atmosphere and outer space. It is established at an altitude of approximately one hundred kilometers above sea level. Above this boundary, aerodynamic lift cannot support aircraft flight, requiring space vehicles to achieve orbital velocity to remain aloft and function properly in space environment.

2. (B) 11.2 km/s
Escape velocity is the minimum speed an unpowered object needs to break free from the gravitational attraction of a celestial body without further propulsion. For Earth, this speed is approximately eleven point two kilometers per second near the surface. Achieving this critical threshold allows space probes and interplanetary vehicles to overcome gravitational pull and journey into deep space.

3. (A) Vikram Sarabhai
Vikram Sarabhai was a visionary scientist recognized as the pioneer of the Indian space initiative. He recognized the immense potential of satellite technology for socio-economic development, leading to the creation of the Indian National Committee for Space Research in 1962. His persistent efforts established foundational research institutions and shaped India's strategic vision for exploring outer space for national growth.

4. (C) Payload
Payload refers to the essential equipment, sensors, cameras, or transponders carried aboard a spacecraft to perform its scientific, operational, or commercial duties. While the spacecraft bus provides structural support, power, thermal control, and attitude management, the payload represents the primary functional component that gathers data, transmits signals, or executes dedicated space research objectives effectively.

5. (A) Moon
The Moon is the sole natural satellite orbiting Earth at an average distance of approximately 384,400 kilometers. Formed over four billion years ago, it exerts a significant gravitational influence that stabilizes Earth's axial tilt and creates ocean tides. Unlike human-made artificial satellites, natural satellites originate through planetary formation mechanisms without human design or technological intervention.

6. (D) A human-made object orbiting a celestial body
An artificial satellite is an engineered object intentionally placed into orbit around Earth or another celestial body. These manufactured devices carry specialized electronic instruments, power systems, and communication equipment to perform specific functions such as telecommunications, meteorological observation, navigation, and astronomical research, distinguishing them from natural space objects like moons, asteroids, and distant planetary systems.

7. (B) Sputnik 1
Sputnik 1 was the world's first artificial satellite, launched into orbit by the Soviet Union on October 4, 1957. The spherical satellite transmitted radio signals back to Earth, proving the viability of satellite communication. This landmark event inaugurated the Space Age, driving technological development and triggering intense geopolitical competition in space exploration between major global powers.

8. (B) 160 km to 2000 km
Low Earth Orbit encompasses altitudes ranging from approximately 160 kilometers to 2,000 kilometers above the Earth's surface. Satellites in this zone move at high velocities, completing an orbital circuit in roughly 90 to 120 minutes. This orbit is widely preferred for Earth observation, remote sensing, spatial mapping, communication constellations, and manned orbital stations like the space station.

9. (D) Geostationary orbit
A geostationary orbit is a circular equatorial orbit where a satellite rotates around the Earth at the exact speed of the planet's rotation. Placed at an altitude of nearly 35,786 kilometers, the satellite matches Earth's 24-hour period,

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Placed predominantly in geostationary orbits, GSAT spacecraft carry high-power transponders across C, Ku, and Ka frequency bands to augment national telecommunication infrastructure across the subcontinent.

68. (C) Geostationary orbit
INSAT and GSAT satellites are placed in geostationary orbit approximately 35,786 kilometers directly above Earth's equator. This orbit matches the planet's rotation rate, allowing the spacecraft to remain continuously fixed relative to ground stations, which is essential for uninterrupted direct-to-home television broadcasting, telecommunication links, and meteorological observation over South Asia.

69. (A) Indian Remote Sensing
IRS stands for Indian Remote Sensing, designating a series of Earth observation satellites deployed by the Indian Space Research Organisation. Placed in Sun-synchronous polar orbits, IRS satellites collect high-resolution spatial, spectral, and temporal imagery used extensively in natural resource management, agricultural planning, forestry monitoring, ocean development, and cartography.

70. (C) Assertion (A) is true but Reason (R) is false.
IRS satellites deliver consistent imagery of Earth's surface due to their systematic orbital ground tracks. However, they are placed in Sun-synchronous polar orbits at low altitudes rather than geostationary orbits. Their polar trajectory enables complete global coverage over continuous orbital cycles under stable solar lighting conditions across the planet.

71. (B) Forest mapping and crop estimation
Indian Remote Sensing satellite imagery is utilized for natural resource management, including forest cover mapping, agricultural crop acreage estimation, soil health evaluation, and surface water inventory. Multi-spectral sensors collect precise reflectance data across land covers, empowering government agencies to assess crop stress, monitor deforestation, and manage land resources effectively.

72. (C) IRS-1A
IRS-1A was India's inaugural operational remote sensing satellite, launched on March 17, 1988, using a Soviet Vostok launch vehicle. Equipped with Linear Imaging Self-Scanning sensors, IRS-1A collected high-resolution multispectral imagery, establishing India's independent capacity for earth observation, land mapping, agricultural inventory, and environmental monitoring from orbit.

73. (D) Gamma band
Commercial telecommunication satellites rely on radio and microwave frequency allocations like C, Ku, and Ka bands to transmit communication signals through the atmosphere. Gamma radiation consists of extremely high-energy ionizing photons that cannot be modulated for signal transmission and are completely absorbed by Earth's atmosphere, rendering them unsuitable for communications.

74. (A) Communication satellites
Very Small Aperture Terminal systems rely on geostationary communication satellites to establish private data networks for banking, digital transactions, remote connectivity, and corporate networks. VSAT ground dishes communicate via transponder channels, enabling reliable two-way data transfer between geographically isolated branches and central processing centers without relying on terrestrial optical fiber.

75. (A) P-2, Q-4, R-3, S-1
Specialized Indian satellite series serve distinct applications. Cartosat platforms provide high-resolution terrain mapping and urban planning imagery. INSAT-3D satellites carry advanced atmospheric sounders and radiometers dedicated to meteorology. GSAT satellites deploy high-power transponders for telecommunication services, while the NavIC constellation provides regional navigation and positioning services across South Asia.

76. (B) Transponders
Satellite mobile telephony and radio broadcasting function by transmitting uplink radio signals to satellite transponders. The transponder converts the frequency, amplifies the weakened radio signal, and retransmits it down across a wide geographic footprint, permitting ground terminals in isolated regions to establish clear communication links without ground infrastructure.

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2013 into geostationary orbit, it provides secure real-time communication capabilities linking Indian naval warships, submarines, aircraft, and shore establishments across the Indian Ocean region to strengthen maritime domain security.

98. (D) Electromagnetic intelligence and radar surveillance
EMISAT is an advanced defense satellite developed jointly by ISRO and DRDO to gather electronic intelligence. Launched into Sun-synchronous polar orbit in April 2019, EMISAT carries a specialized payload designed to intercept, measure, and analyze electromagnetic signals and radar transmissions across border areas, strengthening national defense surveillance capabilities.

99. (A) Encrypted communication and border surveillance
Space technology plays a critical role in modern defense by enabling encrypted tactical communication, real-time border surveillance, and target reconnaissance. Specialized satellites supply military forces with secure data networks, precise positional guidance, high-resolution imagery of strategic locations, and early warning systems, enhancing situational awareness and national security operations.

100. (C) Mission Shakti
Mission Shakti was an anti-satellite missile test conducted by India on March 27, 2019. Executed jointly by DRDO and ISRO, a ballistic missile interceptor neutralized a live test satellite operating in Low Earth Orbit at an altitude of 300 kilometers, establishing India as the fourth nation with anti-satellite weapon capabilities.

101. (A) EDUSAT
GSAT-3, launched by ISRO in September 2004, is famously known as EDUSAT. It was the first Indian satellite built exclusively to serve the educational sector. Positioned in geostationary orbit, EDUSAT facilitated interactive distance learning, educational channel broadcasting, and virtual classrooms across schools, colleges, and universities nationwide.

102. (D) Distance education and virtual learning
EDUSAT was designed specifically to support distance education, interactive virtual learning, and educational broadcasting across India. By deploying transponders in audio-visual networks, it delivered quality educational content, curriculum lectures, and teacher training programs directly to remote rural schools, colleges, and academic institutions that lacked traditional physical educational facilities.

103. (B) By providing satellite connectivity for remote medical consultations
Space technology enables telemedicine by establishing satellite communication links between rural health centers and urban specialty hospitals. Through high-speed satellite connectivity, medical diagnostic data, clinical images, and patient records are transmitted in real time, allowing medical specialists in major cities to conduct remote consultations and direct treatments for patients in underserved areas.

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104. (C) BharatNet
The BharatNet project utilizes satellite communication links to deliver high-speed broadband connectivity to remote Gram Panchayats where terrestrial optical fiber cable laying is difficult due to rough topography. Utilizing high-throughput communication satellites, BharatNet extends digital governance, online public services, and internet access to remote rural communities nationwide.

105. (A) P-2, Q-4, R-1, S-3
Space applications serve diverse social and developmental needs: telemedicine enables remote medical consultation by specialists; tele-education broadcasts interactive lessons to rural schools; disaster management systems issue cyclone alerts to coastal regions; and resource mapping satellites collect spectral data to estimate mineral wealth and forest cover across national territories.

106. (C) Newton's Third Law of Motion
Rocket propulsion operates fundamentally on Newton's Third Law of Motion, which states that every action produces an equal and opposite reaction. Inside a rocket engine, combustion expels high-pressure exhaust gas backward through a nozzle at extreme velocity, creating an equal reaction force that pushes the rocket forward through space.

107. (B) Linear momentum
Rocket propulsion relies on the law of conservation of linear momentum in a closed system. As hot combustion gases are expelled backward at high

87. (B) Kessler Syndrome
The Kessler Syndrome describes a theoretical scenario where the density of artificial space debris in Low Earth Orbit reaches a critical threshold. At this point, orbital collisions generate fragment cascades, causing further impacts in a runaway chain reaction that could render specific orbital altitudes unusable for future satellite operations and human space exploration.

88. (C) Project NETRA
ISRO initiated Project NETRA (Network for space object Tracking and Analysis) to enhance Space Situational Awareness capability. The project establishes radar installations, optical telescopes, and control centers to detect, track, and monitor space debris and inactive satellites, safeguarding Indian operational space assets against potential orbital collisions in space.

89. (D) Low Earth Orbit (LEO)
The International Space Station operates in Low Earth Orbit at an average altitude between 370 and 460 kilometers above Earth. Orbiting within this zone allows convenient crew resupply, maintenance missions, and scientific research under microgravity conditions while completing approximately 15.5 orbits around the Earth every single day.

90. (A) P-4, Q-1, R-2, S-3
Major global space agencies represent specific nations or regional alliances. NASA is the national space agency of the United States. ESA represents a consortium of European countries. JAXA manages space programs for Japan, while Roscosmos oversees space flight, satellite development, and space research infrastructure for the Russian Federation.

91. (B) Microgravity and space research laboratory
The International Space Station functions primarily as a permanently inhabited microgravity research laboratory. Situated in Low Earth Orbit, it enables international scientific research across biology, human physiology, physics, materials science, and astronomy, allowing scientists to conduct long-term experiments that cannot be replicated on Earth's surface due to gravity's interference.

92. (C) 90 minutes
Traveling at an orbital velocity of roughly 28,000 kilometers per hour at a low altitude of about 400 kilometers, the International Space Station takes approximately 90 minutes to complete a single full orbit around Earth. Consequently, crew members aboard the station experience sixteen sunrises and sunsets during a 24-hour day.

93. (B) 104
On February 15, 2017, ISRO achieved a historic milestone by successfully deploying 104 satellites into orbit using a single flight of the PSLV-$C_3$7 rocket from Sriharikota. The mission successfully released Cartosat-2D along with 103 co-passenger nanosatellites from various countries, demonstrating extraordinary precision engineering and commercial satellite launching capability.

94. (C) Rakesh Sharma
Wing Commander Rakesh Sharma became the first Indian citizen to travel into space on April 3, 1984. Flying aboard the Soviet Soyuz T-11 spacecraft as part of a joint Soviet-Indian mission, he spent nearly eight days aboard the Salyut 7 space station performing biomedical research and remote sensing studies.

95. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
ISRO has achieved remarkable commercial success in the global launch market due to the Polar Satellite Launch Vehicle. PSLV offers high reliability, precise orbital placement, and low launching costs, making it a preferred choice for foreign satellite operators seeking cost-effective access to orbit for light and medium class payloads.

96. (C) Vikram-S
Vikram-S was India's first privately developed launch vehicle, constructed by space startup Skyroot Aerospace. Launched successfully on November 18, 2022, from Sriharikota under Mission Prarambh, this single-stage sub-orbital rocket validated core technologies, payload integration, and avionics, opening private commercial rocket launching capabilities in the Indian space sector.

97. (B) Indian Navy
GSAT-7, designated Rukmini, is an advanced military communication satellite built by ISRO specifically for the Indian Navy. Launched in

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heating, solar wind acceleration, coronal mass ejections, and solar magnetic field activity without occultation from Earth.

118. (A) P-3, Q-1, R-4, S-2
India's strategic space targets include diverse exploratory missions: Gaganyaan is engineered for human spaceflight capability into Low Earth Orbit; Shukrayaan is planned as an orbiter mission to Venus; NISAR is a collaborative dual-frequency Earth observation radar mission with NASA; and Mangalyaan-2 is designed as India's second interplanetary mission targeting Mars.

119. (B) Lagrange Point 1
In the Aditya-L_1 mission name, 'L_1' refers to Lagrange Point 1, a gravitationally balanced position located roughly 1.5 million kilometers from Earth towards the Sun. Placing a spacecraft at L_1 permits continuous, unobstructed observation of the Sun without eclipses or occultations, ensuring constant tracking of solar flares and space weather.

120. (C) NASA
NISAR (NASA-ISRO Synthetic Aperture Radar) is a joint Earth-observation mission developed by ISRO and NASA. Utilizing dual-frequency L-band and S-band radar instruments, NISAR maps global surface changes, ice sheet collapse, ecosystem disturbances, groundwater movement, and natural hazards with high spatial precision, illustrating international collaboration in orbital remote sensing.

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velocity, they carry negative linear momentum. To conserve total momentum, the rocket body gains an equal amount of forward linear momentum, accelerating the vehicle through atmosphere and space.

108. (B) Mass flow rate of expelled gases
Thrust generated by a rocket engine is directly proportional to the product of two factors: the mass flow rate of propellant expelled through the nozzle and the effective exhaust velocity of those expelled gases. Increasing either the rate of mass consumption or exhaust velocity produces greater propulsion force for the spacecraft.

109. (A) Because outer space lacks oxygen to support combustion
Rockets must carry an onboard oxidizer in addition to fuel because outer space contains no atmospheric oxygen to sustain chemical combustion. By mixing fuel with an oxidizer in the combustion chamber, rocket engines can ignite, generate hot expanding gas, and produce thrust independently of atmospheric oxygen conditions in vacuum environments.

110. (B) Only I and III
Rockets generate thrust by expelling high-velocity mass backward, and multistage rockets jet off spent fuel tanks to discard unnecessary structural mass during ascent. Conversely, air-breathing jet engines require atmospheric oxygen to burn fuel and cannot operate in vacuum space, which is why rockets must carry their own oxidizers onboard.

111. (D) Weather forecasting that reduces agricultural losses
Satellite-based weather forecasting provides substantial economic benefits by delivering early warnings about severe storms, droughts, and rainfall patterns. Accurate meteorological forecasts enable farmers and agricultural planners to protect crops, optimize harvesting schedules, and prevent significant financial and crop losses caused by unexpected extreme weather events.

112. (C) Spinoff technologies
Spinoff technologies are commercial products and practical innovations originally engineered for space missions that subsequently find widespread application in everyday civilian life. Examples include water purification filters, memory foam, cardiac pacemakers, infrared thermometers, and scratch-resistant lenses, which demonstrate the tangible broader economic and societal value derived from space research investments.

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113. (B) IN-SPACe
IN-SPACe (Indian National Space Promotion and Authorization Centre) was established as an autonomous single-window agency under the Department of Space. Its mandate is to promote, permit, regulate, and handhold private sector space activities in India, offering private enterprises non-discriminatory access to ISRO infrastructure and operational satellite manufacturing capabilities.

114. (D) NewSpace India Limited
NewSpace India Limited (NSIL) was incorporated in 2019 as a wholly owned central public sector enterprise under the Department of Space. Functioning as the commercial arm of ISRO, NSIL spearheads the commercial exploitation of space products, transfers technologies to industry, manufactures rockets through private partners, and provides launch services globally.

115. (A) P-4, Q-2, R-1, S-3
Key Indian space organizations perform specific operational functions: ISRO drives research and development in space technology; NSIL operates as the commercial entity of the Department of Space; IN-SPACe promotes and regulates private industry participation; and the Indian Institute of Remote Sensing delivers specialized education and capacity building in remote sensing applications.

116. (C) To enhance India's global space economy share and foster innovation
Opening the space sector to private companies aims to expand India's share in the global space economy while fostering technological innovation. Private sector participation drives industrial capacity, attracts private investment, lowers operational launch costs, and enables ISRO to focus more resources on advanced research, interplanetary exploration, and strategic space missions.

117. (A) To observe and study the Sun continuously
Aditya-L_1 is India's first dedicated solar space observatory mission, designed to observe and analyze solar dynamics continuously. Positioned in a halo orbit around the Sun-Earth Lagrange Point 1, its primary objective is to study coronal

to transmit data.
II. Web pages are predominantly written using Hypertext Markup Language (HTML).
III. It operates completely offline without needing an active internet connection.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II, and III

11. Which standard protocol is widely used for sending emails across the internet?
(A) FTP
(B) HTTP
(C) VoIP
(D) SMTP

12. In an email interface, what does the BCC field stand for?
(A) Blind Carbon Copy
(B) Basic Carbon Copy
(C) Broadcast Carbon Copy
(D) Blind Communication Channel

13. Which of the following represents a positive social impact of social media?
(A) Uncontrolled dissemination of unverified online rumors
(B) Rapid mobilization during natural emergency situations
(C) Significant reduction in direct face-to-face communication
(D) Increased vulnerability to severe online cyberbullying

14. Which of the following platforms is primarily known as a professional networking social media site rather than a general photo-sharing app?
(A) Instagram
(B) LinkedIn
(C) Snapchat
(D) Pinterest

15. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Email filters automatically move bulk unsolicited messages into a separate "Spam" folder.
Reason (R): Spam emails often contain malicious links or phishing attempts that can harm user security.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

16. Which prominent e-governance initiative by the Government of Rajasthan acts as a unified service delivery platform for citizens?
(A) DigiLocker
(B) SWAYAM
(C) e-Mitra
(D) e-NAM

17. The flagship "Digital India" campaign was launched by the Government of India in which year?
(A) 2010
(B) 2012
(C) 2018
(D) 2015

18. Online payment of property taxes by a citizen to the municipal corporation is an example of which e-governance model?
(A) G2B (Government to Business)
(B) G2G (Government to Government)
(C) G2C (Government to Citizen)
(D) B2C (Business to Citizen)

19. Which of the following is NOT one of the core vision areas of the Digital India programme?
(A) Digital infrastructure as a core utility to every citizen
(B) Providing free smartphones to every global citizen
(C) Governance and services on demand
(D) Digital empowerment of citizens

20. Match List I with List II.
List I: (E-governance Initiative)
P. Jan Aadhaar (Rajasthan)
Q. DigiLocker
R. UMANG
S. Jan Soochna Portal
List II: (Function)
1. Authentic digital document storage
2. Single window for all government apps
3. Transparency and Right to Information delivery in Rajasthan
4. Unified identity card for families in Rajasthan
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-4, S-3

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CHAPTER 09
Information Technology

1. Which of the following best defines Information Technology (IT)?
(A) The study of living organisms and their cellular structures
(B) The process of manufacturing heavy industrial machinery and automobiles
(C) The study of fundamental particles and their interactions in a vacuum
(D) The use of computers, storage, networking, and physical devices to create, process, store, secure, and exchange electronic data

2. Which of the following is an example of system software rather than application software?
(A) Microsoft Word
(B) Google Chrome
(C) Operating System
(D) Adobe Photoshop

3. Which of the following components is NOT considered computer hardware?
(A) Motherboard
(B) Antivirus Program
(C) Central Processing Unit
(D) Random Access Memory

4. Find the odd one out among the following computer input devices.
(A) Keyboard
(B) Mouse
(C) Barcode Reader
(D) Monitor

5. Match List I with List II.
List I: (Computer Component)
P. Printer
Q. Windows 11
R. MS Excel
S. Scanner
List II: (Category)
1. System Software
2. Input Device
3. Output Device
4. Application Software
(A) P-3, Q-1, R-4, S-2
(B) P-2, Q-4, R-1, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

6. What does the term "Internet" fundamentally refer to?
(A) A single high-powered supercomputer maintained by government agencies
(B) A private local network restricted entirely to a single office building
(C) A global network of interconnected computer networks using TCP/IP
(D) A specialized software utility designed for creating digital graphics

7. Who is globally credited with the invention of the World Wide Web (WWW)?
(A) Tim Berners-Lee
(B) Bill Gates
(C) Steve Jobs
(D) Charles Babbage

8. Consider the following statements about the Internet and World Wide Web (WWW):
Statement I: The Internet and the World Wide Web are exactly the same thing.
Statement II: The World Wide Web is a collection of linked documents accessed via the Internet.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct
(B) Both Statement I and Statement II are incorrect
(C) Statement I is correct but Statement II is incorrect
(D) Statement I is incorrect but Statement II is correct

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9. In the context of the World Wide Web, what is the full form of URL?
(A) Universal Resource Locator
(B) Uniform Resource Locator
(C) United Route Link
(D) Uniform Routing Language

10. Consider the following statements regarding the features of the World Wide Web:
I. It uses Hypertext Transfer Protocol (HTTP)

(A) Information represents raw unorganized facts, whereas data is fully processed and structured knowledge.
(B) Data consists of raw unorganized facts, while information is processed data that conveys clear meaning.
(C) Data strictly requires a computer to process, whereas information can only be recorded on physical paper.
(D) There is no fundamental difference; both terms are used completely interchangeably in computer science.

32. In computer terminology, what does DBMS stand for?
(A) Data Backup and Management System
(B) Digital Business Maintenance Software
(C) Database Management System
(D) Data Broadcasting Media System

33. In a relational database, what is the role of a "Primary Key"?
(A) It securely encrypts all data stored within the database
(B) It automatically deletes duplicate data files from memory
(C) It establishes a direct network connection to the internet
(D) It uniquely identifies each individual record in a table

34. Consider the following statements regarding databases:
Statement I: A database allows for efficient retrieval, insertion, and deletion of data.
Statement II: MS Access and MySQL are examples of Database Management Systems.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct
(B) Both Statement I and Statement II are incorrect
(C) Statement I is correct but Statement II is incorrect
(D) Statement I is incorrect but Statement II is correct

35. Consider the following statements regarding the advantages of using a database:
I. It significantly reduces data redundancy (duplication).
II. It allows multiple users to access data simultaneously.
III. It guarantees that computer hardware will never fail.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II, and III

36. Which type of cybercrime involves sending fraudulent emails that appear to be from reputable sources to steal sensitive data like passwords?
(A) Cyberstalking
(B) Phishing
(C) Piracy
(D) Cryptomining

37. What is the primary purpose of an antivirus software?
(A) To detect, prevent, and remove malware from a computer system
(B) To optimize and significantly increase internet connection speeds
(C) To design and develop secure web pages for corporate websites
(D) To generate automated backup copies of large network databases

38. The core principles of cybersecurity are often referred to as the CIA triad. What does CIA stand for?
(A) Control, Information, Access
(B) Cyber, Internet, Authentication
(C) Confidentiality, Integrity, Availability
(D) Confidentiality, Investigation, Authorization

39. Find the odd one out from the following list of malicious threats.
(A) Firewall
(B) Trojan Horse
(C) Ransomware
(D) Worm

40. Which of the following sequences represents the correct increasing order of data storage capacity?
(A) Kilobyte < Megabyte < Gigabyte < Terabyte
(B) Megabyte < Kilobyte < Terabyte < Gigabyte
(C) Gigabyte < Terabyte < Megabyte < Kilobyte
(D) Kilobyte < Gigabyte < Megabyte < Terabyte

41. Which of the following best describes "Ransomware"?
(A) Security software utilized exclusively by government agencies to protect public data
(B) Malware that encrypts files and demands

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(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

21. What does the term "Telemedicine" refer to in the context of healthcare?
(A) Providing remote clinical healthcare services via telecommunication tools
(B) Manufacturing pharmaceutical products through automated robotic systems
(C) Purchasing prescription drugs online via digital mobile pharmacy apps
(D) The specialized medical study of radioactive substances and isotopes

22. Which portal was launched by the Ministry of Education (India) to provide digital infrastructure for school education and e-learning?
(A) eSanjeevani
(B) e-NAM
(C) DIKSHA
(D) VAHAN

23. Which of the following is a primary benefit of telemedicine?
(A) Enables remote consultations with specialist doctors without long travel
(B) Completely eliminates the requirement for invasive surgical procedures
(C) Directly cures all complex viral infections using digital technology
(D) Fully replaces the necessity for physical medical learning institutions

24. Which technology relies on live, two-way interaction between teachers and students via the internet in real-time?
(A) Asynchronous e-learning
(B) Offline learning
(C) Print-based distance education
(D) Synchronous e-learning

25. Given below are steps involved in a standard telemedicine consultation:
I. Receiving a digital prescription from the doctor
II. Registering on the telemedicine portal
III. Booking a time slot for consultation
IV. Engaging in a live video call with the physician
Which of the following options represents the correct chronological order of the above steps?
(A) II, III, IV, I
(B) III, II, I, IV
(C) II, IV, III, I
(D) IV, III, II, I

26. In the Indian banking system, what does NEFT stand for?
(A) National Economic Finance Transaction
(B) Network Exchange Funds Transfer
(C) National Electronic Funds Transfer
(D) Nominal Electronic Finance Trade

27. An individual selling their old bicycle directly to another individual on an online platform like OLX is an example of which e-commerce model?
(A) B2B (Business to Business)
(B) B2C (Business to Consumer)
(C) C2B (Consumer to Business)
(D) C2C (Consumer to Consumer)

28. What is the full form of CBS, a widely used technology framework in modern banking?
(A) Core Banking Solution
(B) Centralized Banking System
(C) Corporate Business Server
(D) Custom Banking Software

29. Which of the following is NOT typically a feature of e-commerce?
(A) Continuous round-the-clock availability of services
(B) Strict geographical limits on product marketing
(C) Integrated electronic online payment processing
(D) Global market reach and rapid business expansion

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30. Match List I with List II.
List I: (E-commerce Model)
P. B2B
Q. B2C
R. C2C
S. G2C
List II: (Example)
1. Paying electricity bills on a state portal
2. An individual selling old books to another on eBay
3. A wholesaler ordering bulk goods from a manufacturer online
4. A customer buying a shirt from Amazon
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-4, R-2, S-3

31. What is the primary difference between data and information?

77. (A) Assessing crop health and acreage using remote sensing
Space technology serves agriculture primarily through satellite remote sensing, which measures spectral reflectance from vegetation canopies. Earth observation satellites allow agronomists to evaluate crop health, estimate acreage, detect pest infestations, monitor soil moisture, and forecast yield potential across regional scales, enabling data-driven agricultural management and crop insurance operations.

78. (C) Normalized Difference Vegetation Index
NDVI stands for Normalized Difference Vegetation Index, a standardized numerical index calculated from satellite imagery using red and near-infrared light reflectance. Healthy chlorophyll absorbs red light and strongly reflects near-infrared energy, allowing scientists to assess vegetation density, monitor crop vigor, detect drought stress, and manage agricultural resources.

79. (D) INSAT
The INSAT satellite series, including meteorological platforms like INSAT-3D and INSAT-3DR, provides critical imagery for tracking tropical cyclones across the Indian Ocean. Operating from geostationary orbit, these satellites capture continuous visible and thermal infrared imagery, helping meteorologists track storm formation, intensity, trajectory, and landfall timing for disaster management.

80. (C) 2, 1, 4, 3
Effective satellite-based disaster management follows a logical progression. First, satellite imagery of an affected region is acquired. Next, specialists analyze the imagery to conduct damage assessment. Following analysis, timely disaster warnings are disseminated to authorities and local populations, enabling targeted relief and rescue operations to be deployed on the ground.

81. (B) NavIC
India's independent regional navigation satellite system is named NavIC, an acronym for Navigation with Indian Constellation, officially recognized as IRNSS. Designed by ISRO, NavIC delivers accurate real-time positioning, navigation, and timing services over India and surrounding regions, reducing dependency on foreign satellite navigation constellations for critical applications.

82. (B) 7
The primary constellation of NavIC consists of seven operational satellites positioned in high-altitude orbits. Three of these satellites reside in geostationary orbit over the Indian Ocean, while the remaining four are placed in inclined geosynchronous orbits. This arrangement provides continuous regional geometry for precise spatial location positioning across India.

83. (A) Geostationary and Geosynchronous
NavIC satellites operate in high-altitude geostationary and geosynchronous orbits approximately 35,786 kilometers above Earth. A combination of three geostationary satellites along the equatorial plane and four inclined geosynchronous satellites in figure-eight orbital tracks maintains optimal signal visibility over the primary Indian operational coverage footprint continuously day and night.

84. (B) 1500 km
The primary service area of NavIC encompasses the entire Indian landmass and extends outward up to approximately 1,500 kilometers beyond the nation's international boundaries. This extended regional coverage ensures reliable navigation, timing, and spatial positioning services across South Asia, surrounding ocean waters, and neighboring border regions for strategic and commercial purposes.

85. (A) Only I and II
NavIC provides precise position information services in India using two service tiers: Standard Positioning Service for open civilian access and Restricted Service for authorized defense applications. However, NavIC is a regional navigation system designed for South Asia rather than a global constellation that fully replaces GPS everywhere worldwide.

86. (D) Non-functional human-made space objects
Space debris refers to artificial, non-functional human-made objects orbiting the Earth. It comprises inactive satellites, spent rocket upper stages, operational fragments, paint flakes, and collision fragments. Traveling at high orbital speeds in Low Earth Orbit, space debris poses serious collision risks to operational satellites, spacecraft, and manned orbital platforms.

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payment for access restoration
(C) A system optimization utility that enhances the processing speed of mobile devices
(D) A subscription-free cloud storage platform designed for remote file management

42. In network security, what is a firewall primarily designed to do?
(A) Regulate and reduce internal heat generated by the computer CPU
(B) Enhance visual output and graphics processing performance of systems
(C) Monitor and filter network traffic based on defined security rules
(D) Automatically generate and manage encrypted user account passwords

43. What does "Digital Privacy" primarily concern?
(A) The right of individuals to own multiple personal computers privately
(B) Physical security of computer hardware located inside a private office
(C) The legal right to download digital media over private local networks
(D) Protection of personal information shared across digital networks

44. Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) are primary service models of which technology?
(A) Cloud Computing
(B) Blockchain
(C) Artificial Intelligence
(D) Virtual Reality

45. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cloud computing allows users to access their files from any device across the world.
Reason (R): Cloud computing relies on physical hard drives carried by the user at all times.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

46. Which of the following is a common example of a public cloud storage service used by everyday consumers?
(A) Linux
(B) MS Paint
(C) Google Drive
(D) Adobe Reader

47. How has Information Technology enhanced the Right to Information (RTI) process in India?
(A) By completely replacing physical paper currency with digitized central bank tokens
(B) By automatically publishing all confidential state secrets onto public social media
(C) By permanently shutting down public government departments that fail to respond promptly
(D) By enabling citizens to file and track RTI applications online via portals

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48. Artificial Intelligence (AI) is best defined as:
(A) Simulation of human intelligence processes by computer systems
(B) A mechanical robotic system incapable of autonomous decision making
(C) A physical networking cable designed to connect two computer systems
(D) A biological brain directly integrated into an electronic mainframe

49. Which of the following is a widely known example of an AI-powered conversational assistant?
(A) MS DOS
(B) Notepad
(C) VLC Media Player
(D) ChatGPT

50. Match List I with List II.
List I: (Mobile Technology Generation)
P. 1G
Q. 2G
R. 3G
S. 4G
List II: (Key Feature)
1. Introduced SMS and digital voice (GSM)
2. Analog voice calls only
3. True broadband speeds with LTE
4. Introduced mobile internet and video calling
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

51. In the context of mobile telecommunications, what does GSM stand for?
(A) General Standard for Mobile Communications
(B) Global System for Mobile Communications

(B) Four dot-separated numeric octets (e.g., 192.168.1.1)
(C) A structured set of random English dictionary words separated by commas
(D) Six pairs of alphanumeric hexadecimal digits separated by punctuation colons

74. In web browsing, what does HTTP stand for?
(A) Hyper Text Transmission Protocol
(B) High Technology Transfer Protocol
(C) Hyper Text Transfer Protocol
(D) Hyperlink Transfer Technology Protocol

75. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Web browsers often display a padlock icon when a user visits a website starting with HTTPS.
Reason (R): HTTPS uses encryption to secure the communication between the browser and the web server.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

76. When sending an email, what does the CC field indicate?
(A) Carbon Copy
(B) Contact Copy
(C) Confidential Copy
(D) Computer Copy

77. Which of the following social media platforms is best known as a "microblogging" site?
(A) YouTube Video Platform
(B) X (Twitter)
(C) WhatsApp Messenger
(D) Pinterest Pinboard

78. Which wide area network initiative by the Rajasthan government connects Gram Panchayats to provide seamless e-governance services?
(A) BharatNet Only
(B) RajNet
(C) BSNL WAN
(D) RajWeb

79. The primary function of the Digital India initiative 'DigiLocker' is to:
(A) Store authentic digital documents and certificates
(B) Provide an official financial platform for citizens to purchase digital gold
(C) Offer free streaming of commercial movies and digital entertainment content
(D) Act as an online e-commerce marketplace for ordering daily groceries

80. Match List I with List II.
List I: (Social Media Platform)
P. YouTube
Q. WhatsApp
R. Instagram
S. Blogger
List II: (Primary Content Type)
1. Instant Messaging
2. Video Sharing
3. Long-form text articles
4. Photo and Reel Sharing
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-1, S-3

81. eSanjeevani, launched by the Ministry of Health and Family Welfare, is a national flagship portal for:
(A) E-commerce and retail distribution of heavy medical equipment
(B) Issuing and managing universal public health insurance policies
(C) Telemedicine and remote medical consultations
(D) Providing physical practical training for hospital nursing staff

82. In the context of e-learning, what does MOOC stand for?
(A) Modern Offline Organized Class
(B) Mobile Operating Online Code
(C) Massive Open Online Course
(D) Multiple Option Online Course

83. In online banking security, an OTP is often sent to a user's mobile phone as part of Two-Factor Authentication. What does OTP stand for?
(A) Online Transaction Password
(B) One-Time Password
(C) Open Telecommunication Protocol
(D) Only Tested Password

84. Which entity in e-commerce acts as a digital bridge between a merchant's website and the bank to authorize credit card or UPI payments?

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(D) Completely banning foreign social media platforms across the country

62. Which primary legislation governs cybercrimes and electronic commerce in India?
(A) The Consumer Protection Act, 2019
(B) The Information Technology Act, 2000
(C) The Digital India Act, 2022
(D) The Indian Penal Code, 1860 (exclusively)

63. Which Indian city is historically referred to as the "Silicon Valley of India" due to its dominant IT industry growth?
(A) Bengaluru
(B) Mumbai
(C) New Delhi
(D) Jaipur

64. What is the role of NASSCOM in the Indian IT sector?
(A) The central government administrative ministry responsible for regulating internet speeds
(B) A malicious financial computer virus that historically targeted Indian banking institutions
(C) Premier trade body and chamber of commerce for India's tech industry
(D) A newly launched open-source desktop operating system developed for Indian government offices

65. Match List I with List II.
List I: (IT/Tech Term)
P. Start-up India
Q. Make in India
R. STPI
S. CERT-In
List II: (Description)
1. Encourages manufacturing in India
2. Software Technology Parks of India
3. Promotes entrepreneurship and new tech ventures
4. Nodal agency for cyber security emergencies
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

66. The gap between those who have access to modern information and communication technology and those who do not is known as the:
(A) Digital Divide
(B) Cyber Gap
(C) Analog Boundary
(D) Technological Wall

67. The DPDP Act, recently enacted in India, deals with which aspect of IT?
(A) Digital Payments and Duties Protection
(B) Digital Personal Data Protection
(C) Direct Public Digital Procurement
(D) Distributed Protocol Data Parsing

68. Which emerging technology relies on a decentralized, distributed, and public digital ledger to record transactions securely across many computers?
(A) Artificial Intelligence
(B) Virtual Reality
(C) 3D Printing
(D) Blockchain

69. In the context of future IT trends, what does IoT stand for?
(A) Internet of Things
(B) Internet of Technology
(C) Intranet of Telecom
(D) Internal Optimization Tool

70. Which of the following is a negative social impact of prolonged and unmonitored use of information technology?
(A) Significantly improved real-time global communication across borders
(B) Easier and faster access to diverse digital educational resources
(C) Sedentary lifestyle and related physical health issues
(D) Faster execution of online financial and banking transactions

71. Find the odd one out from the following list of computer output devices.
(A) Webcam
(B) Display Monitor
(C) Laser Printer
(D) Audio Speaker

72. Which of the following is a correct pair of an application software and its primary function?
(A) MS PowerPoint — Creating spreadsheets
(B) Linux — Editing videos
(C) MySQL — Creating graphical presentations
(D) Adobe Reader — Viewing PDF documents

73. What is the standard format of an IPv4 address?
(A) A single continuous long string composed strictly of alphabetical characters

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(C) Gigabyte System Network Infrastructure
(D) Global Satellite Telecommunication Module

52. Consider the following statements about Machine Learning (ML):
Statement I: Machine Learning is a subset of Artificial Intelligence.
Statement II: In Machine Learning, algorithms improve their performance based on data rather than being explicitly programmed for every scenario.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct
(B) Both Statement I and Statement II are incorrect
(C) Statement I is correct but Statement II is incorrect
(D) Statement I is incorrect but Statement II is correct

53. What does LAN stand for in computer networking?
(A) Local Area Network
(B) Large Area Network
(C) Logical Access Node
(D) Limited Area Network

54. The global Internet is considered the largest example of which type of network?
(A) PAN (Personal Area Network)
(B) LAN (Local Area Network)
(C) WAN (Wide Area Network)
(D) CAN (Campus Area Network)

55. Identify the incorrect statement regarding network topologies.
(A) A LAN cannot use a Star topology as it requires satellite access.
(B) In a Star topology, every individual node connects directly to a central hub or switch.
(C) In a Bus topology, all connected network devices share a single main communication cable.
(D) In a Ring topology, all network devices are connected in a continuous closed-loop fashion.

56. What is the main function of a router in a computer network?
(A) To generate and print physical paper copies of digital documents
(B) To supply continuous electrical power directly to network cables
(C) To act as a primary offline optical storage device for servers
(D) Forward data packets between different computer networks

57. Which government portal/initiative facilitates online trading of agricultural commodities by connecting APMC mandis across India?
(A) e-RTO (Regional Transport Office Portal)
(B) e-NAM (National Agriculture Market)
(C) DigiLocker (Digital Document Repository)
(D) VAHAN (National Vehicle Registry Portal)

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58. The concept of using GPS, sensors, and IT tools to ensure that crops and soil receive exactly what they need for optimum health and productivity is known as:
(A) Traditional Farming
(B) Shifting Cultivation
(C) Precision Agriculture
(D) Slash and Burn Agriculture

59. The current trend of automation and data exchange in manufacturing technologies, including IoT and cloud computing, is popularly termed as:
(A) Industry 1.0
(B) The Agricultural Revolution
(C) Green Revolution
(D) Industry 4.0

60. Consider the following statements regarding the use of IT in modern industry:
I. IT helps in supply chain management through real-time tracking.
II. Computer-Aided Design (CAD) software is used heavily in industrial product design.
III. Automation through IT has eliminated the need for electrical power in factories.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II, and III

61. PMGDISHA is a flagship scheme by the Government of India aimed at which of the following?
(A) Providing free high-speed fiber broadband internet to all urban households
(B) Making six crore rural citizens digitally literate
(C) Establishing massive hyperscale cloud data centers in every rural village

(A) Web Browser
(B) Search Engine
(C) Logistics Partner
(D) Payment Gateway

85. Consider the following statements about Unified Payments Interface (UPI):
I. It allows real-time fund transfer between bank accounts through a mobile platform.
II. It requires the sender to know the recipient's exact bank account number and IFSC code for every transaction.
III. It operates 24x7 and 365 days a year.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only I and III
(C) Only II and III
(D) I, II, and III

86. In database management, SQL is the standard language used to communicate with the database. What does SQL stand for?
(A) Standardized Database Query Language
(B) Sequential Data Query Link
(C) Structured Query Language
(D) Server System Question Language

87. A thermometer records a temperature of 38°C. This specific numerical value is an example of _____, while a doctor concluding the patient has a fever based on this value is an example of _____.
(A) Data; Information
(B) Information; Data
(C) Database; Software
(D) Output; Input

88. A cyber attack that floods a website with massive traffic, causing it to crash and become unavailable to legitimate users, is known as:
(A) Fraudulent Phishing Attack
(B) Passive Network Eavesdropping
(C) Financial Salami Slicing Scam
(D) Denial of Service (DoS)

89. The process of converting readable data into an unreadable format to prevent unauthorized access during transmission is called:
(A) Decryption
(B) Encryption
(C) Compression
(D) Formatting

90. Which of the following represents the correct standard hierarchy of data organization from smallest to largest?
(A) Bit < Byte < Field < Record < File < Database
(B) Byte < Bit < Record < Field < File < Database
(C) Bit < Byte < File < Record < Field < Database
(D) Field < Bit < Byte < Record < Database < File

91. A malicious computer program that disguises itself as legitimate software but secretly provides unauthorized access to the user's system is known as a:
(A) Network Firewall
(B) Tracking Cookie
(C) Code Debugger
(D) Trojan

92. In digital privacy, what is a "cookie"?
(A) A text file stored by websites to remember preferences and track activity
(B) A destructive computer virus designed specifically to physically ruin hardware
(C) An encrypted online payment gateway infrastructure deployed in e-commerce stores
(D) A detailed diagnostic system scan report generated by security antivirus tools

93. A cloud infrastructure provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units) is known as a:
(A) Public Cloud
(B) Private Cloud
(C) Community Cloud
(D) Open Cloud

94. The famous test proposed to determine if a machine can demonstrate human-like intelligence in conversation is called the:
(A) Babbage Test
(B) Turing Test
(C) Lovelace Protocol
(D) Einstein Paradigm

95. Match List I with List II.
List I: (Cyber Threat)
P. Spyware
Q. Adware
R. Ransomware
S. Worm
List II: (Definition)

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services accessed over this global network using web browsing application software.

9. (B) Uniform Resource Locator
A Uniform Resource Locator serves as a standardized reference address used to identify and locate specific digital resources across the web. It specifies the protocol required to access the resource, along with the domain name or IP address and the precise file path. This uniform web addressing format enables browsers to seamlessly request and retrieve web pages worldwide.

10. (A) Only I and II
The World Wide Web relies on standardized technical specifications to deliver digital media across global networks. It utilizes Hypertext Transfer Protocol to manage client-server communication and data transfer. Web pages are constructed using Hypertext Markup Language to structure text, links, and multimedia content. Active internet network connections are essential, making offline operation fundamentally impossible for accessing web documents.

11. (D) SMTP
Simple Mail Transfer Protocol is the standard TCP/IP network protocol designed specifically for transmitting outgoing electronic mail messages across networks. It governs how mail servers route and exchange messages between sender and recipient domains. While incoming email retrieval relies on protocols like POP3 or IMAP, SMTP remains the primary universal protocol for outgoing email transfer across the internet.

12. (A) Blind Carbon Copy
Blind Carbon Copy is a standard feature in email communication interfaces that allows a sender to forward duplicate copies of a message to multiple recipients discreetly. Addresses entered into this specific field remain completely hidden from all other message recipients. This privacy mechanism prevents recipient address exposure and reduces spam risk during bulk organizational message distribution.

13. (B) Rapid mobilization during natural emergency situations
Social media platforms facilitate real-time communication, rapid information dissemination, and community coordination during crisis scenarios. During natural disasters and public emergencies, these digital platforms enable emergency responders, relief agencies, and affected citizens to coordinate rescue efforts, share life-saving updates, and mobilize emergency resources rapidly. This instant connectivity represents a crucial positive social benefit of modern networked communication.

14. (B) LinkedIn
LinkedIn is a specialized social networking platform designed specifically for professional career development, executive networking, recruitment, and business collaboration. Unlike general photo-sharing platforms oriented around casual media consumption, it enables individuals to build professional profiles, display occupational credentials, connect with industry colleagues, apply for career opportunities, and share corporate knowledge across business communities globally.

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15. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Automated email filtering systems utilize security algorithms to analyze incoming messages and automatically redirect bulk unsolicited communications into designated spam folders. This automated protection mechanism is implemented because unsolicited bulk emails frequently carry cyber threats, including malicious hyperlinks, dangerous attachments, and fraudulent phishing schemes designed to compromise user accounts, harvest credentials, and disrupt enterprise communication channels.

16. (C) e-Mitra
Launched by the Government of Rajasthan, e-Mitra is a comprehensive e-governance platform designed to deliver diverse public services through unified online portals and physical service kiosks. It enables citizens across urban and rural areas to pay utility bills, apply for government certificates, access social welfare benefits, and submit official applications efficiently without visiting multiple administrative departments.

17. (D) 2015
The Government of India officially launched the flagship Digital India programme in July 2015. Designed to transform the country into a digitally empowered society and knowledge economy, the initiative focuses on creating robust digital infrastructure, delivering government services

Reason (R): In a blockchain, data is stored in a centralized server controlled by a single administrator.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

106. The technology that overlays digital information and graphics onto the real physical world through a device's camera (e.g., Pokémon GO) is known as:
(A) Virtual Reality (VR) Environment
(B) Machine Learning (ML) Algorithm
(C) Augmented Reality (AR)
(D) Quantum Computing Infrastructure

107. Which internet connection technology utilizes optical fibers to transmit data as pulses of light?
(A) Dial-up Connection
(B) Satellite Internet
(C) Coaxial Cable Network
(D) Fiber-optic

108. Software that is permanently embedded into a hardware device's non-volatile memory (like a ROM chip) to control how the device operates is known as:
(A) Firmware
(B) Shareware
(C) Freeware
(D) Malware

109. Which mobile app was developed by the Government of India to provide citizens with access to multiple pan-India e-governance services on a single platform?
(A) Paytm
(B) UMANG
(C) IRCTC Connect
(D) Zomato

110. Consider the following statements about the benefits of the Digital India campaign:
I. It has increased transparency in government processes by reducing manual intervention.
II. It has led to the growth of digital payment infrastructure like UPI.
III. It has completely eliminated illiteracy across the entire country.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I and III
(D) I, II, and III

111. Learning modules where students can view pre-recorded lectures, read materials, and complete assignments at their own pace without live interaction is called:
(A) Synchronous Direct Learning
(B) Asynchronous Learning
(C) Traditional Classroom Learning
(D) Broadcast Distance Learning

112. An 11-character alphanumeric code used in India to uniquely identify a bank branch participating in electronic funds transfer systems (NEFT/ RTGS) is the:
(A) PAN Code
(B) PIN Code
(C) IFSC Code
(D) MICR Code

113. In a database, "Data Redundancy" refers to:
(A) The permanent loss of data caused by hard drive hardware failure
(B) The physical transmission speed at which data is retrieved
(C) The cryptographic process of securing and encrypting stored data
(D) Unnecessary duplication of data

114. A cybercriminal acquiring an individual's personal information (like Aadhaar or PAN details) to impersonate them and commit financial fraud is an example of:
(A) Academic Plagiarism
(B) System Data Backup
(C) Identity Theft
(D) Online Cyberbullying

115. Match List I with List II.
List I: (File Extension)
P. .jpg
Q. .pdf
R. .mp3
S. .docx
List II: (Standard File Type)
1. Audio File
2. Image File
3. Word Processing Document
4. Portable Document Format
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-1, R-4, S-3

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1. Self-replicating malware that spreads across networks
2. Software that secretly monitors user activity
3. Software that displays unwanted advertisements
4. Malware that locks files until money is paid

(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-1, Q-4, R-3, S-2
(D) P-2, Q-4, R-3, S-1

96. Mobile phones use a small smart card to identify the subscriber on a network. What does SIM stand for?
(A) Secure Internet Media Protocol
(B) Standard Information Mode System
(C) Smart Interface Network Module
(D) Subscriber Identity Module

97. In computer networking, every Network Interface Card (NIC) has a unique physical hardware address known as the:
(A) Internet Protocol Address
(B) Uniform Resource Locator
(C) Hypertext Transfer Protocol
(D) MAC Address

98. A network that connects computers within a city or a large campus, being larger than a LAN but smaller than a WAN, is known as a:
(A) PAN
(B) SAN
(C) MAN
(D) CAN

99. How is IT actively being integrated into Indian agriculture for crop monitoring and targeted pesticide spraying?
(A) By completely replacing natural soil with computerized digital circuits
(B) Through agricultural Kisan Drones
(C) By enforcing strict legal bans on internet access in rural farming villages
(D) Through immersive virtual reality video games played by farm workers

100. Given below are four types of computer networks:
I. Wide Area Network (WAN)
II. Personal Area Network (PAN)
III. Metropolitan Area Network (MAN)
IV. Local Area Network (LAN)
Which of the following options represents the correct increasing order of their typical geographical coverage area?
(A) II, IV, III, I
(B) IV, II, I, III
(C) II, III, IV, I
(D) IV, III, II, I

101. Which of the following skills is a critical component of digital literacy in the modern era?
(A) Identifying and verifying reliable online information
(B) The specialized ability to write low-level machine assembly code manually
(C) Knowing how to physically repair and solder a damaged computer motherboard
(D) Demonstrating physical typing speed exceeding 100 words per minute on keyboards

102. What is the primary role of CERT-In (Computer Emergency Response Team) in India's IT policy framework?
(A) To issue and renew motor vehicle driving licenses through digital portals
(B) To domestically manufacture electronic semiconductor processors for computers
(C) National agency for responding to computer security incidents
(D) To regulate retail pricing structures for consumer mobile internet data plans

103. Ergonomics in the context of information technology primarily addresses:
(A) Designing workspaces to minimize physical strain and injuries
(B) Evaluating the environmental ecological impact of disposing old computer hardware
(C) Measuring the physical speed at which data packets travel through optical fibers
(D) Developing advanced cryptographic encryption protocols implemented in cloud systems

104. The Supreme Court of India declared the Right to Privacy as a fundamental right under which Article of the Constitution, heavily influencing digital data protection policies?
(A) Article 14
(B) Article 19
(C) Article 32
(D) Article 21

105. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Blockchain technology is highly resistant to unauthorized data modification.

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ANSWERS

1. (D) The use of computers, storage, networking, and physical devices to create, process, store, secure, and exchange electronic data
Information technology encompasses the comprehensive utilization of computer hardware, software systems, telecommunication networks, and digital infrastructure. It focuses on facilitating the complete lifecycle of electronic data, including its generation, processing, secure transmission, and persistent storage. This field forms the core operational foundation for modern digital communication, commercial enterprise infrastructure, and computerized administrative management systems globally.

2. (C) Operating System
An operating system is essential system software designed to manage computer hardware resources, control memory, and provide foundational operational services for application programs. Unlike specialized end-user productivity tools like word processors or web browsers, an operating system serves as a primary intermediary interface between physical machinery and software applications, maintaining essential background stability and process management.

3. (B) Antivirus Program
Computer hardware comprises the physical, tangible components of a computer system, such as circuit boards, microprocessors, integrated memory modules, power supply units, and peripheral devices. Conversely, security applications, including antivirus software utilities, represent intangible sets of executable code instructions designed to safeguard system data and fall under the classification of software programs rather than physical hardware.

4. (D) Monitor
Computer input devices are hardware peripherals utilized to enter raw data, user commands, and control signals into a processing system. Keyboards, mice, and barcode scanners collect external information for computer interpretation. Conversely, display visual screens function as output devices because they receive processed electronic signals from system graphics hardware and project visual data outward to human users.

5. (A) P-3, Q-1, R-4, S-2
A printer produces physical paper output from digital files, functioning as an output device. Windows 11 serves as an operating system that manages system hardware resources. Microsoft Excel is an application software utilized for spreadsheet creation and data analysis. A scanner captures physical documents and converts them into digital format, acting as an input hardware device for computing systems.

6. (C) A global network of interconnected computer networks using TCP/IP
The Internet is a massive, globally distributed infrastructure of interconnected computer networks that communicate using standardized networking protocols, primarily Transmission Control Protocol and Internet Protocol. It links billions of public, private, academic, commercial, and government devices worldwide. This extensive electronic network facilitates seamless resource sharing, distributed computing, instant communication, and global digital information transfer across diverse geographical regions.

7. (A) Tim Berners-Lee
British scientist Sir Tim Berners-Lee invented the World Wide Web in 1989 while working at CERN. He created the essential technologies that powered the web, including Hypertext Transfer Protocol, Hypertext Markup Language, and Uniform Resource Locators. His revolutionary vision established an open, interconnected information space that allowed users globally to navigate linked digital documents across the internet.

8. (D) Statement I is incorrect but Statement II is correct
The Internet and the World Wide Web are distinct concepts rather than identical entities. The Internet is the underlying physical global network infrastructure connecting millions of computers. Conversely, the World Wide Web is an information space consisting of interlinked web documents, multimedia content, and digital

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(D) P-1, Q-4, R-3, S-2

116. Bluetooth technology is widely used to create which type of short-range network?
(A) Wide Area Network (WAN Infrastructure)
(B) Storage Area Network (SAN Storage)
(C) Personal Area Network (PAN)
(D) Value Added Network (VAN Service)

117. In industrial IT applications, what does ERP stand for?
(A) Enterprise Resource Planning
(B) Electronic Recording Program
(C) Energy Resource Provision
(D) Essential Routing Protocol

118. Under modern data protection and privacy laws, an organization must obtain clear permission from a user before collecting their personal data. This principle is known as:
(A) Encryption
(B) Tokenization
(C) User Consent
(D) Data Mining

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119. A major environmental and social concern arising from the rapid upgrading and disposal of IT hardware (computers, phones, servers) is known as:
(A) E-waste (Electronic waste)
(B) Digital Atmospheric Smog
(C) Cybernetic Environmental Pollution
(D) Hardware Resource Depletion

120. In the field of future IT trends, "Big Data" is commonly characterized by three V's. Which of the following represents these three V's?
(A) Value, Vision, Vector
(B) Virtual, Visible, Verified
(C) Variable, Vocal, Valid
(D) Volume, Velocity, Variety

electronically, enhancing public digital literacy, and expanding high-speed internet connectivity across all rural and urban regions nationwide.

18. (C) G2C (Government to Citizen)
Government-to-Citizen e-governance models encompass digital services provided directly by state or local administrative authorities to individual residents. When a citizen utilizes an online government portal to submit municipal property tax payments, file official applications, or access public service records, the transaction exemplifies a direct electronic interaction between a public government institution and a citizen consumer.

19. (B) Providing free smartphones to every global citizen
The Digital India framework centers on three core vision areas: establishing digital infrastructure as a basic utility, offering governance and public services on demand, and achieving digital empowerment for domestic citizens. Providing free mobile hardware to citizens globally falls outside its mandate, as the national policy focuses strictly on domestic digital infrastructure, public accessibility, and national e-governance implementation.

20. (A) P-4, Q-1, R-2, S-3
Jan Aadhaar provides a unified single identifier for families in Rajasthan to access welfare benefits. DigiLocker offers cloud-based digital document storage for authentic certificates. UMANG acts as a unified mobile app aggregating hundreds of central and state government services. Jan Soochna Portal delivers proactive disclosure of government scheme details, promoting transparency and Right to Information implementation.

21. (A) Providing remote clinical healthcare services via telecommunication tools
Telemedicine utilizes advanced telecommunication technologies and digital electronic networks to deliver remote clinical medical care, expert consultations, diagnostic reviews, and health monitoring. It bridges geographical barriers by enabling healthcare professionals to evaluate, diagnose, and treat patients living in remote or underserved areas without requiring physical travel to specialized medical institutions or centralized healthcare facilities.

22. (C) DIKSHA
DIKSHA is a national digital platform created by the Ministry of Education in India to support school education and teacher professional development. It provides interactive digital learning materials, open textbooks, aligned curricula, and educational resources accessible to students, teachers, and parents across diverse languages and educational boards nationwide via web portals and mobile applications.

23. (A) Enables remote consultations with specialist doctors without long travel
Telemedicine significantly enhances healthcare access by enabling remote video consultations between medical specialists and patients residing in distant or rural locations. This digital interaction eliminates physical travel requirements, reduces associated medical transportation costs, accelerates diagnostic evaluation times, and ensures timely clinical advice for individuals who lack direct physical access to specialized healthcare institutions in urban centers.

24. (D) Synchronous e-learning
Synchronous e-learning refers to real-time educational instruction where teachers and students interact simultaneously through digital platforms, such as live video conferencing tools, virtual classrooms, or instant chat sessions. This mode enables immediate feedback, interactive discussions, live collaborative problem-solving, and active engagement, requiring participants to log in and participate during scheduled session hours concurrently.

25. (A) II, III, IV, I
Participating in a telemedicine medical consultation follows a systematic process. First, a user registers an account on the designated medical service portal. Next, the patient books a suitable appointment time slot with a specialist physician. Then, the live video consultation takes place between doctor and patient. Finally, the user receives an authentic electronic prescription digitally.

26. (C) National Electronic Funds Transfer
National Electronic Funds Transfer is a nationwide electronic payment system operated by the Reserve Bank of India. It enables individuals, businesses, and corporate entities to transfer funds electronically between bank accounts

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101. (A) Identifying and verifying reliable online information
Modern digital literacy encompasses essential cognitive and analytical skills required to locate, evaluate, verify, and utilize digital information effectively. A primary aspect involves critically analyzing online content, identifying reliable news sources, recognizing misinterpretation or fake news, and safely navigating web environments while maintaining digital ethics, personal privacy, and cybersecurity awareness.

102. (C) National agency for responding to computer security incidents
The Indian Computer Emergency Response Team functions as the national nodal government agency responsible for cybersecurity threat management under the Ministry of Electronics and Information Technology. CERT-In analyzes cyber attack patterns, issues security advisories, tracks vulnerability exposures, and coordinates emergency response operations during major network security breaches across the country.

103. (A) Designing workspaces to minimize physical strain and injuries
Ergonomics in IT focuses on designing computer hardware, office furniture, input accessories, and working environments to match human physical capabilities. By optimizing seating posture, monitor viewing angles, keyboard placement, and lighting, ergonomic design reduces physical fatigue, minimizes repetitive strain injuries, and enhances overall comfort and productivity during prolonged computer usage.

104. (D) Article 21
In the landmark Justice K. S. Puttaswamy judgment, the Supreme Court of India unanimously declared the Right to Privacy as a fundamental right guaranteed under Article 21 of the Constitution, which protects the Right to Life and Personal Liberty. This historic legal ruling fundamentally shaped national digital privacy policy and data protection legislation.

105. (C) Assertion (A) is true but Reason (R) is false.
Blockchain technology maintains high resistance against unauthorized data modifications due to cryptographic hashing algorithms and distributed consensus protocols. However, blockchain relies on a decentralized network model where identical data ledgers are replicated across multiple peer nodes globally, making the claim that it relies on a centralized server controlled by a single administrator factually incorrect.

106. (C) Augmented Reality (AR)
Augmented Reality is a immersive digital technology that overlays computer-generated graphic images, 3D visual models, or digital information onto the real physical world in real time through camera displays on smartphones or specialized headsets. Unlike virtual reality, which creates fully artificial digital environments, augmented reality enhances human perception of actual surroundings.

107. (D) Fiber-optic
Fiber-optic internet transmission technology utilizes thin strands of glass or transparent plastic fibers to transmit data as rapid pulses of light. Operating through total internal reflection, fiber-optic communication provides ultra-fast internet speeds, exceptionally high bandwidth capacity, low signal degradation, and minimal electromagnetic interference across long distance network connections.

108. (A) Firmware
Firmware refers to specialized low-level control software embedded directly into hardware devices' non-volatile memory chips, such as Read-Only Memory. It provides essential operational instructions, hardware initialization routines, and basic input/output controls that enable electronic equipment—ranging from microprocessors and computer motherboards to digital household appliances—to operate reliably and interface with operating systems.

109. (B) UMANG
Unified Mobile Application for New-age Governance is a mobile application launched by the Government of India to offer single-window access to multi-level public services. UMANG integrates hundreds of central and state government e-governance services, allowing citizens to access healthcare, education, utility bill payments, social welfare, and administrative applications seamlessly on one platform.

110. (A) Only I and II
The Digital India initiative has streamlined public governance by digitizing administrative processes, which enhances institutional transparency and drastically reduces manual delays. It has also catalyzed the rapid adoption

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prevents inconsistent duplicate records across applications. Additionally, concurrent access controls enable multiple authorized users to query and update the database simultaneously. However, databases are software platforms that cannot guarantee physical hardware against operational equipment failure or physical breakdown.

36. (B) Phishing
Phishing is a social engineering cybercrime where attackers deploy deceptive electronic communications, such as fraudulent emails or fake website links, disguised as legitimate institutions. The objective is to trick unsuspecting individuals into revealing sensitive private credentials, financial details, passwords, or personal identity numbers, which are subsequently exploited for unauthorized access or financial fraud.

37. (A) To detect, prevent, and remove malware from a computer system
Antivirus software is a cybersecurity utility program engineered to protect computer operating systems against malicious software threats. It continuously scans storage media, active memory, downloaded files, and inbound network traffic to identify, isolate, quarantine, and eliminate harmful viruses, software worms, trojans, ransomware, and spyware threats before they compromise system functionality or data security.

38. (C) Confidentiality, Integrity, Availability
The CIA triad represents the foundational security model for information security architectures. Confidentiality ensures that sensitive data remains restricted to authorized users only. Integrity guarantees that stored or transmitted data remains accurate, complete, and uncorrupted by unauthorized modification. Availability ensures that systems, services, and networks remain continuously accessible to legitimate users whenever operational needs arise.

39. (A) Firewall
A firewall is a network security utility designed to defend computing systems by monitoring and filtering network traffic according to predefined security rules. Unlike malicious threats like Trojan horses, ransomware programs, and self-replicating worms designed to compromise, encrypt, or damage electronic data, a firewall acts as a protective defense barrier against unauthorized digital network incursions.

40. (A) Kilobyte < Megabyte < Gigabyte < Terabyte
Digital computer storage capacity is measured in standardized binary units. A kilobyte equals 1,024 bytes. A megabyte is equivalent to 1,024 kilobytes. A gigabyte consists of 1,024 megabytes. A terabyte represents 1,024 gigabytes. Therefore, organizing these primary storage units by capacity in ascending numerical order produces the sequence: Kilobyte, Megabyte, Gigabyte, and Terabyte.

41. (B) Malware that encrypts files and demands payment for access restoration
Ransomware is a dangerous category of malicious software that infects computing systems, encrypts critical user files, and restricts system access using complex cryptographic algorithms. Cybercriminals then demand digital ransom payments from victims in exchange for decryption keys. It poses severe threats to organizational data integrity, business continuity, operational infrastructure, and personal digital security worldwide.

42. (C) Monitor and filter network traffic based on defined security rules
A network firewall functions as an essential security boundary between trusted internal networks and untrusted external networks, such as the public internet. It continuously inspects inbound and outbound data packets against established security policies, automatically blocking suspicious, malicious, or unauthorized network communications while permitting legitimate data transfers to pass through safely.

43. (D) Protection of personal information shared across digital networks
Digital privacy pertains to the protection of personally identifiable information, online behavior records, communication logs, and sensitive personal data collected or shared across digital platforms and networked communication environments. It involves managing how individual user data is gathered, processed, shared, stored, and protected against unauthorized surveillance, commercial exploitation, data leaks, and cyber criminal misuse.

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across participating branches. Transactions are processed securely in half-hourly batches, facilitating efficient, standardized, and safe interbank money transfers across the Indian financial network.

27. (D) C_2C (Consumer to Consumer)
Consumer-to-Consumer e-commerce involves commercial transactions conducted directly between private individuals, typically facilitated by a third-party online platform or marketplace software. When an individual lists a personal item, such as a used bicycle, on a digital platform and sells it directly to another private individual, the transaction exemplifies a classic C_2C business model interaction.

28. (A) Core Banking Solution
Core Banking Solution refers to a centralized networking platform deployed by modern financial institutions that enables bank branches to interconnect and share customer account databases in real time. It allows account holders to perform banking operations, access financial services, execute money transfers, and process transactions seamlessly from any networked branch location across the entire banking institution.

29. (B) Strict geographical limits on product marketing
E-commerce leverages digital communication networks and web platforms to conduct business transactions across global borders without traditional location constraints. Unlike physical storefronts limited by local geography, online commercial platforms offer continuous, round-the-clock service availability, integrated electronic payment processing systems, and expansive market visibility that allows businesses to reach worldwide customer bases effortlessly across regions.

30. (A) P-3, Q-4, R-2, S-1
B2B involves commercial transactions between businesses, such as a wholesaler purchasing bulk items from a manufacturer. B2C occurs when a consumer buys goods directly from an online retail vendor. C_2C represents private individual transactions, like selling pre-owned items on eBay. G2C involves citizens utilizing official government platforms to complete public payments or services online.

31. (B) Data consists of raw unorganized facts, while information is processed data that conveys clear meaning.
Data represents unorganized, raw facts, individual measurements, or isolated values that lack contextual meaning on their own. In contrast, information refers to data that has been systematically collected, processed, organized, structured, and interpreted within a specific context. Processing transforms raw values into meaningful knowledge that enables informed human analysis, structured reporting, and strategic decision-making.

32. (C) Database Management System
A Database Management System is a specialized software application framework designed to define, create, maintain, manipulate, and organize large structured data repositories. It serves as an interface between end-users, application programs, and underlying physical storage, providing tools for data query processing, concurrency control, security enforcement, data integrity maintenance, and automated system backup routines.

33. (D) It uniquely identifies each individual record in a table
In relational database architecture, a primary key is a designated column or set of columns containing values that uniquely identify each individual row or record within a data table. It enforces data integrity by strictly preventing duplicate entries or null values, facilitating precise record retrieval and establishing logical relationships with foreign keys across tables.

34. (A) Both Statement I and Statement II are correct
A database framework enables efficient data operations, allowing authorized users to rapidly insert new records, update existing information, retrieve specific queries, and delete data securely. Widely used relational software systems, such as Microsoft Access for small desktop environments and MySQL for multi-user enterprise environments, are standard Database Management Systems designed to manage structured tables.

35. (A) Only I and II
Database management systems offer significant operational advantages by centralizing data storage, which minimizes data redundancy and

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53. (A) Local Area Network
Local Area Network refers to a computer network that interconnects communication devices within a limited geographical area, such as a single office building, home, laboratory, or school campus. LANs deliver high data transmission speeds, low data latency, and localized resource sharing, including shared printer access and local file server management.

54. (C) WAN (Wide Area Network)
A Wide Area Network spans vast geographical regions, connecting smaller networks across cities, countries, or entire continents. The global Internet serves as the largest and most comprehensive example of a Wide Area Network, utilizing satellite links, transoceanic fiber-optic cables, and routing hardware to interconnect millions of private, public, and institutional networks worldwide.

55. (A) A LAN cannot use a Star topology as it requires satellite access.
Star topology is one of the most common physical layouts utilized in Local Area Networks, where each network node connects directly to a central networking switch or hub using standard twisted-pair cables. Satellite connectivity is not required for localized Star topology configurations, as data routing occurs locally through the central hardware device within the network.

56. (D) Forward data packets between different computer networks
A network router is a specialized hardware networking device that operates at the network layer to direct data traffic between distinct computer networks. It analyzes packet header destination IP addresses, evaluates network routing tables, and forwards data packets along optimal path trajectories to ensure accurate data transmission across interconnected local and wide area networks.

57. (B) e-NAM (National Agriculture Market)
National Agriculture Market is an online pan-India electronic trading portal launched by the Government of India. It integrates physical Agricultural Produce Market Committee mandis across various states into a unified digital market network, promoting uniform trade procedures, enhancing price discovery transparency, and facilitating direct digital bidding and agricultural trading for farmers nationwide.

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58. (C) Precision Agriculture
Precision Agriculture is a modern farm management concept that utilizes information technology, Global Positioning System mapping, satellite imagery, Internet of Things sensors, and variable-rate technology. These tools analyze localized spatial soil variability, monitor crop health, and optimize agricultural inputs such as water, fertilizers, and pesticides to maximize crop yields while conserving resources.

59. (D) Industry 4.0
Industry 4.0 signifies the modern industrial revolution characterized by the integration of advanced digital technologies into manufacturing and production processes. It combines industrial Internet of Things connectivity, cloud computing infrastructure, real-time data analytics, artificial intelligence, robotics, and cyber-physical systems to establish smart factories capable of autonomous operation, predictive maintenance, and optimized resource allocation.

60. (A) Only I and II
Information Technology optimizes industrial operations through real-time supply chain tracking systems and computer-aided design software for complex product engineering. However, introducing automated digital control systems, industrial robotics, and computing infrastructure requires consistent, reliable electrical power, rendering the idea that automation completely eliminates electrical energy requirements in industrial manufacturing facilities entirely incorrect.

61. (B) Making six crore rural citizens digitally literate
Pradhan Mantri Gramin Digital Saksharta Abhiyaan is an initiative under the Digital India campaign. Designed specifically to bridge the digital gap in rural communities, the scheme aims to impart functional digital literacy to six crore rural household members, training them to operate digital devices, browse the internet, access e-governance services, and perform cashless digital financial transactions securely.

62. (B) The Information Technology Act, 2000
The Information Technology Act, 2000 is the primary legal statute in India governing electronic commerce, digital signatures, electronic record authentications, and cybercrime regulation. It establishes the legal framework for recognizing

44. (A) Cloud Computing
Software as a Service, Platform as a Service, and Infrastructure as a Service represent the three principal service architecture models of cloud computing technology. These delivery frameworks allow organizations and end-users to access scalable computing infrastructure, software development environments, and application software on demand over the internet without owning or managing physical servers directly.

45. (C) Assertion (A) is true but Reason (R) is false.
Cloud computing provides remote network access to centralized software, computing infrastructure, and storage systems, enabling users to access personal files globally from any internet-connected device. However, this functionality relies on remote data center servers managed by cloud service providers, completely eliminating the need for users to carry physical hard drives or external storage hardware.

46. (C) Google Drive
Google Drive is a widely used public cloud storage service that allows users to upload, store, organize, edit, and share files online. It provides synchronized access to digital documents, images, and media across connected personal computers, tablets, and smartphones, storing data on secure remote servers managed by the cloud service vendor.

47. (D) By enabling citizens to file and track RTI applications online via portals
Information Technology has modernized public administration by digitizing the Right to Information process through dedicated web portals. These online platforms enable citizens to submit information requests, upload necessary documents, make fee payments securely, and track application processing status in real time, thereby enhancing government transparency, operational accountability, and public accessibility across state institutions.

48. (A) Simulation of human intelligence processes by computer systems
Artificial Intelligence represents a branch of computer science focused on developing advanced hardware and software systems capable of synthesizing cognitive functions historically associated with human intelligence. These capabilities include learning from data inputs, abstract reasoning, pattern recognition, problem-solving, natural language comprehension, decision-making, and autonomous adaptation to dynamic environments without continuous manual intervention.

49. (D) ChatGPT
Developed by OpenAI, ChatGPT is a prominent artificial intelligence chatbot powered by advanced large language models. It uses deep learning algorithms to process natural language inputs, engage in coherent interactive conversations, generate textual responses, answer complex analytical queries, and assist users across diverse educational, technical, and creative writing applications in real time.

50. (A) P-2, Q-1, R-4, S-3
First-generation mobile technology utilized analog radio signals strictly for voice communication. Second-generation networks introduced digital transmission, enabling SMS text messaging and GSM voice standards. Third-generation networks introduced mobile internet access and video calling functionality. Fourth-generation networks introduced high-speed broadband wireless standards like Long-Term Evolution to handle heavy mobile data applications.

51. (B) Global System for Mobile Communications
Global System for Mobile Communications is an international standard established for second-generation digital cellular networks. It introduced digital voice encryption, time-division multiple access technology, Short Message Services, and subscriber identity cards, revolutionizing global mobile communications by replacing legacy analog systems with secure, standardized, and interoperable cellular network protocols worldwide.

52. (A) Both Statement I and Statement II are correct
Machine Learning operates as a specialized subfield within Artificial Intelligence. Rather than relying on hardcoded rules or explicit programming instructions for every situation, machine learning algorithms analyze large training datasets to identify underlying patterns, make statistical predictions, and iteratively improve performance and accuracy on target tasks through continuous automated exposure to new data.

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and images from the physical environment and converting them into digital signal inputs for processing.

72. (D) Adobe Reader — Viewing PDF documents
Adobe Reader is an application software tool specifically engineered for viewing, printing, signing, and annotating digital documents stored in Portable Document Format. Other paired tools served different functions; PowerPoint is designed for visual presentations, Linux is an open-source operating system rather than a video editor, and MySQL operates as a relational database system.

73. (B) Four dot-separated numeric octets (e.g., 192.168.1.1)
Internet Protocol version 4 addresses utilize a 32-bit numerical addressing architecture divided into four 8-bit segments known as octets. Each octet is represented in decimal format ranging from 0 to 255 and separated by period dots. This standardized numeric notation allows routing equipment to identify unique hardware interfaces connected to IP-based networks globally.

74. (C) Hyper Text Transfer Protocol
Hypertext Transfer Protocol serves as the foundational application-layer protocol utilized by the World Wide Web to structure network communications. It defines standard rules for formatting and transmitting messages between web clients and servers, governing how browsers request web resources and how web servers deliver requested HTML documents and multimedia content across internet connections.

75. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Modern web browsers display a secure padlock icon in the address bar when connected to websites operating over Hypertext Transfer Protocol Secure. This visual security indicator signifies that the underlying connection utilizes cryptographic encryption standards, safeguarding data transmissions between browser and server against unauthorized eavesdropping, data interception, or malicious modification by third parties.

76. (A) Carbon Copy
Carbon Copy is an email header field used to send transparent duplicate copies of a message to secondary recipients. Unlike Blind Carbon Copy, every email address listed in the CC field remains fully visible to all message recipients, making it suitable for keeping team members or stakeholders informed during general organizational communication workflows.

77. (B) X (Twitter)
X, formerly known as Twitter, is a widely recognized microblogging platform designed for publishing brief real-time text updates, media attachments, and hyperlinks called posts or tweets. Its character-limited format emphasizes rapid public message delivery, instant news sharing, and active online public discussions, distinguishing it from traditional long-form blogging or primary media-sharing sites.

78. (B) RajNet
RajNet is a wide area network initiative established by the Government of Rajasthan to create a unified telecommunications network infrastructure. Connecting state administrative offices, district headquarters, block levels, and Gram Panchayats, it facilitates reliable voice, video, and electronic data transmission to ensure seamless delivery of e-governance services across the state.

79. (A) Store authentic digital documents and certificates
DigiLocker is a key cloud initiative under the Digital India campaign designed to offer secure, paperless document storage and verification. It provides citizens with a personal digital wallet linked to their Aadhaar, enabling government agencies to issue and store authentic official certificates, academic records, and identification documents in a verified digital format.

80. (A) P-2, Q-1, R-4, S-3
YouTube functions primarily as a digital video hosting and streaming platform. WhatsApp operates as an instant messaging service enabling real-time text, voice, and media communication. Instagram focuses on visual media sharing through photos and short video reels. Blogger provides web publishing tools designed specifically for writing, publishing, and hosting long-form online text articles.

81. (C) Telemedicine and remote medical consultations
eSanjeevani is a flagship national telemedicine portal operated by the Ministry of Health and

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digital transactions, protecting administrative networks against cyber security breaches, defining legal penalties for digital offenses, and safeguarding computer networks across the nation.

63. (A) Bengaluru
Bengaluru, the capital city of Karnataka, is globally recognized as the Silicon Valley of India due to its central role as the nation's leading information technology hub. The city houses major global technology corporations, software development centers, innovative technology startups, software engineering research institutes, and extensive digital infrastructure, driving national software exports.

64. (C) Premier trade body and chamber of commerce for India's tech industry
The National Association of Software and Service Companies is the premier non-profit trade association and chamber of commerce representing India's technology and software services sector. It plays a pivotal role in policy advocacy, industry research, talent development, international trade promotion, startup support, and shaping global technological strategies for the Indian software industry.

65. (A) P-3, Q-1, R-2, S-4
Startup India fosters entrepreneurship by supporting innovation ventures. Make in India encourages domestic manufacturing and investment. Software Technology Parks of India promotes software development and export infrastructure. Computer Emergency Response Team India functions as the national nodal government agency responsible for monitoring, analyzing, and responding to cyber security threats and emergency incidents nationwide.

66. (A) Digital Divide
The Digital Divide refers to the socioeconomic inequality between demographic groups, regions, or communities regarding their access to, use of, or knowledge of modern information and communication technologies. This technological gap typically stems from economic disparities, lack of digital infrastructure in rural areas, educational variances, and unequal access to high-speed internet connectivity.

67. (B) Digital Personal Data Protection
The Digital Personal Data Protection Act establishes a legal framework in India for processing personal digital data. It balances the fundamental right of individuals to protect their private personal data with the necessity of processing personal information for legitimate administrative and business purposes, establishing strict legal obligations for data fiduciaries and enforcing user consent.

68. (D) Blockchain
Blockchain is a decentralized, distributed, public digital ledger technology that records data transactions securely across a network of computers. Each transaction block is cryptographically linked to the previous block, creating an immutable chronological chain. This structure ensures high data integrity, fault tolerance, operational transparency, and tamper-resistant security without requiring centralized administrative oversight.

69. (A) Internet of Things
Internet of Things describes a global network of interconnected physical devices, including household appliances, industrial machinery, vehicle sensors, and wearable electronics. Embedded with sensors, software, processing units, and network connectivity, these smart devices collect, transmit, and exchange data seamlessly over the internet to enable automated control, monitoring, and operational optimization.

70. (C) Sedentary lifestyle and related physical health issues
Excessive, unmonitored screen time and prolonged reliance on information technology often promote a sedentary lifestyle among users. Continuous sitting during computer work or digital device usage can lead to adverse physical health impacts, including chronic musculoskeletal strain, eye fatigue, cardiovascular risks, reduced physical fitness, and disrupted natural sleep cycles across various demographic age groups.

71. (A) Webcam
Computer output hardware presents processed data to users, as demonstrated by display screens projecting graphics, printers rendering physical paper documents, and audio speakers emitting sound signals. Conversely, a webcam functions as an input peripheral device, capturing live video

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files are logically organized into a comprehensive database structure.

91. (D) Trojan
A Trojan horse is a type of malicious software that deceives users by disguising itself as legitimate or harmless computer software. Once installed, it executes malicious background tasks, opening unauthorized backdoors into the system, exposing private data to remote attackers, and enabling unauthorized control without user knowledge or consent.

92. (A) A text file stored by websites to remember preferences and track activity
In web browsing, a cookie is a small text file saved on a user's computer by web servers via the web browser. It stores persistent user preferences, session identifiers, shopping cart contents, and browsing activity details, allowing websites to recognize return visitors, maintain active user logins, and customize online user experiences.

93. (B) Private Cloud
A Private Cloud is a specialized cloud deployment model provisioned exclusively for the use of a single organization comprising multiple business units. Managed internally or by third parties, it offers enhanced data privacy, customizable network architecture, dedicated infrastructure resources, and tight security controls, isolating operational enterprise workloads from public multi-tenant environments.

94. (B) Turing Test
Proposed by mathematician Alan Turing in 1950, the Turing Test evaluates whether a machine can exhibit intelligent human behavior during natural language conversations. In this test, a human judge engages in text communication with human and machine subjects; if the judge cannot reliably distinguish machine responses from human responses, the machine passes.

95. (A) P-2, Q-3, R-4, S-1
Spyware secretly monitors digital activity and gathers personal user information. Adware automatically generates and displays unwanted commercial advertisements on computer screens. Ransomware encrypts operational data files and demands monetary ransom for access restoration. A worm is a self-replicating malicious program that autonomously spreads duplicate copies across network connections.

96. (D) Subscriber Identity Module
A Subscriber Identity Module is a smart integrated circuit card used in mobile communication devices to identify and authenticate subscribers on cellular networks. It securely stores network identification parameters, International Mobile Subscriber Identity numbers, cryptographic security keys, personal contact entries, and short message data required for mobile network connectivity.

97. (D) MAC Address
A Media Access Control address is a unique 48-bit physical identifier assigned to a Network Interface Card by its manufacturer. Written as six pairs of hexadecimal digits, it functions at the data link layer to ensure accurate hardware-level address identification and data packet delivery across local physical network segments.

98. (C) MAN
A Metropolitan Area Network is a high-speed computer network spanning a town, city, or large university campus. Larger than a Local Area Network but smaller than a Wide Area Network, a MAN interconnects multiple localized networks to facilitate efficient regional communication, public municipal connectivity, and shared enterprise network resources.

99. (B) Through agricultural Kisan Drones
Agriculture in India increasingly incorporates information technology through Kisan Drones equipped with high-resolution camera sensors and automated spray systems. These specialized agricultural drones monitor crop growth, assess field health, detect pest infestations early, and execute precision spraying of liquid fertilizers and pesticides, improving operational farming efficiency while minimizing chemical waste.

100. (A) II, IV, III, I
Computer networks vary in physical coverage area. A Personal Area Network covers short ranges around an individual. A Local Area Network spans small localized spaces like single office buildings. A Metropolitan Area Network covers entire municipal cities or towns. A Wide Area Network provides the largest coverage, connecting networks across countries and global continents.

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Family Welfare in India. It facilitates remote medical consultations by connecting patients and primary healthcare centers directly with medical specialists through secure digital video conferencing, enabling doctor-to-doctor and patient-to-doctor interactions without requiring physical patient travel to healthcare facilities.

82. (C) Massive Open Online Course
Massive Open Online Course refers to an interactive web-based educational delivery model designed for large-scale interactive participation and open web access. Platforms hosting these courses provide video lectures, reading materials, problem sets, and interactive user forums, allowing thousands of students worldwide to enroll, acquire skills, and complete educational programs remotely without physical classroom attendance.

83. (B) One-Time Password
A One-Time Password is an automatically generated numeric or alphanumeric string used to authenticate a single login session or transaction on digital financial platforms. Sent via SMS or authenticator apps, it serves as a dynamic security layer in multi-factor authentication, protecting user accounts against unauthorized access, credential theft, and fraudulent online transactions.

84. (D) Payment Gateway
A Payment Gateway is a specialized e-commerce service application that securely processes digital transactions between online merchant platforms and financial banking institutions. It encrypts sensitive financial information, such as credit card or payment credentials, and transmits payment requests to acquiring banks for authorization, ensuring safe and efficient online electronic fund transfers.

85. (B) Only I and III
Unified Payments Interface is a real-time instant payment platform operating continuous 24x7 financial transfer services via mobile applications. Users can complete transactions instantly using Virtual Payment Addresses, QR codes, or mobile numbers without sharing detailed recipient account numbers or IFSC codes, rendering the requirement for revealing full banking information for every transaction incorrect.

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86. (C) Structured Query Language
Structured Query Language is the standardized domain-specific programming language used to communicate with, manage, and manipulate relational database management systems. SQL provides standardized commands for querying complex datasets, inserting new records, updating existing entries, modifying database schemas, and defining database access control permissions across administrative enterprise software platforms.

87. (A) Data; Information
A raw numerical temperature reading like 38°C represents uninterpreted data because it provides an isolated measurement without clinical context. Conversely, when a healthcare professional evaluates this numeric measurement within a medical context and determines that the patient displays a fever, the structured interpretation transforms raw data into actionable clinical information.

88. (D) Denial of Service (DoS)
A Denial of Service attack is a malicious cyber intrusion designed to render online services, servers, or web applications unavailable to legitimate users. Attackers achieve this by flooding targeted network interfaces or web servers with overwhelming volumes of fake traffic packets, exhausting system computing resources, bandwidth, and processing capacity, ultimately causing systems to crash.

89. (B) Encryption
Encryption is a fundamental cryptographic process that converts plaintext data into unreadable ciphertext format using mathematical encryption algorithms and security keys. It prevents unauthorized parties from interpreting sensitive digital information during network transmission or storage, ensuring data confidentiality and security across public communication channels until authorized recipients decrypt it using matching keys.

90. (A) Bit $<$ Byte $<$ Field $<$ Record $<$ File $<$ Database
Data organization follows a structured hierarchical structure. A bit is the smallest binary unit, and eight bits combine to form a byte. Bytes compose characters that form a field. Related fields form a record, multiple related records create a file, and interconnected

of digital financial infrastructures like UPI. However, digital governance programs alone cannot completely eliminate social illiteracy across the nation, making that specific assertion incorrect.

111. (B) Asynchronous Learning
Asynchronous learning is a student-centered digital instructional method where educational materials, pre-recorded video lectures, assignments, and reading resources are accessible online at any time. Learners engage with course content and complete evaluations at their own individual pace without requiring simultaneous real-time live interaction with teachers or classmates.

112. (C) IFSC Code
The Indian Financial System Code is an 11-character alphanumeric identifier assigned by the Reserve Bank of India to uniquely identify specific bank branches participating in electronic funds transfer systems. The code structures the routing of electronic money transfers, facilitating safe and accurate automated funds settlement via NEFT, RTGS, and IMPS payment networks.

113. (D) Unnecessary duplication of data
In database management, data redundancy refers to the unnecessary duplication of identical data across multiple tables or files within a system. Uncontrolled redundancy wastes physical disk storage space, introduces data inconsistencies, increases the risk of data corruption, and complicates database updating routines, necessitating normalization techniques to structure databases efficiently.

114. (C) Identity Theft
Identity theft occurs when a cybercriminal illegally obtains personal sensitive information, such as Aadhaar details, social security numbers, or banking credentials, to impersonate an individual without authorization. Attackers exploit this stolen personal information to commit financial fraud, execute illegal online purchases, secure unauthorized loans, or open fraudulent bank accounts illegally.

115. (A) P-2, Q-4, R-1, S-3
Standard file extensions identify specific digital document formats. The .jpg extension designates compressed digital image files. The .pdf format represents universal Portable Document Format files. The .mp3 extension denotes compressed digital audio files. The .docx format indicates word processing text documents created using Microsoft Word software applications.

116. (C) Personal Area Network (PAN)
Bluetooth is a short-range wireless communication technology operating via radio frequencies to interconnect personal electronic devices over short distances. It is primarily utilized to construct Personal Area Networks, enabling seamless data transfer and peripheral communication between personal smartphones, wireless headphones, smartwatches, laptops, and peripheral hardware components without physical cabling.

117. (A) Enterprise Resource Planning
Enterprise Resource Planning refers to integrated software systems utilized by organizations to automate, manage, and optimize core operational business processes. ERP platforms unify diverse organizational functions, including supply chain management, financial accounting, human resources, procurement, manufacturing operations, and inventory management, into a centralized, real-time shared database architecture.

118. (C) User Consent
Modern data privacy frameworks enforce the fundamental principle of user consent, which mandates that organizations obtain explicit, informed permission from individuals before collecting, storing, or processing their personal data. This requirement empowers consumers to maintain control over their private personal information and restricts unauthorized commercial data collection and tracking.

119. (A) E-waste (Electronic waste)
Electronic waste refers to discarded electronic equipment, hardware, and digital devices, including obsolete computers, discarded mobile phones, printed circuit boards, and server hardware. Rapid technological advancement and short device lifecycles generate massive e-waste volumes, posing severe environmental risks and health hazards due to toxic heavy metals if not recycled through regulated channels.

120. (D) Volume, Velocity, Variety
Big Data is fundamentally defined by three primary characteristics known as the Three V's:

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82. Out of the 23 pairs of chromosomes in a normal human cell, how many pairs are autosomes?
(A) 21 pairs
(B) 22 pairs
(C) 23 pairs
(D) 1 pair

83. The English physician Archibald Garrod is often regarded as the father of human genetics because he discovered that the disease alkaptonuria is inherited as a Mendelian recessive trait. Alkaptonuria is an example of an:
(A) Acquired transmissible infectious disease
(B) Systemic chronic autoimmune disorder
(C) Non-heritable environmental disease
(D) Inborn metabolic error

84. In humans, a male child always inherits his X chromosome directly from his:
(A) Mother
(B) Father
(C) Paternal grandfather
(D) Either father or mother randomly

85. Consider the following statements regarding the ABO blood group system:
I. The allele IA produces antigen A on red blood cells.
II. The allele i does not produce any surface antigen.
III. The alleles IA and IB are incompletely dominant over each other, blending to make blood group AB.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

86. In a human pedigree chart, a horizontal line connecting a male symbol and a female symbol indicates:
(A) Mating or marriage
(B) They are siblings
(C) They are parent and child
(D) They are monozygotic twins

87. A double horizontal line between a male and a female in a pedigree chart specifically represents:
(A) Mating that produces dizygotic non-identical twins
(B) Formal legal separation or divorce of partners
(C) Two distinct offspring originating from the same parental pair
(D) Consanguineous mating between closely related individuals

88. In the standard symbols used for pedigree analysis, a circle represents:
(A) A male
(B) A female
(C) Sex unspecified
(D) An affected individual

89. In a pedigree chart, a diamond shape indicates:
(A) An affected female
(B) A carrier male
(C) Sex unspecified
(D) Death of the individual

90. Match the pedigree symbols in List I with their correct meaning in List II.
List I:
P. Square
Q. Circle
R. Diamond
S. Shaded symbol
List II:
1. Female
2. Affected individual
3. Male
4. Sex unspecified
(A) P-1, Q-3, R-2, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-3, Q-1, R-4, S-2

91. A sudden, heritable change in the DNA sequence or genetic material of an organism is termed:
(A) Mutation
(B) Translation
(C) Crossing over
(D) Transcription

92. Genetic variation during gamete formation is primarily generated by a process where homologous chromosomes exchange segments. This process is called:
(A) Segregation
(B) Crossing over (Recombination)
(C) Non-disjunction
(D) Epistasis

93. Continuous variations in a natural population are typically primarily caused by:
(A) Lethal mutations
(B) Genetic recombination and independent assortment
(C) Polyploidy

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CHAPTER 10

Genetic Terminology and Mendel's Laws

1. The branch of biology that deals with the study of heredity and variation is known as:
(A) Cytology
(B) Evolution
(C) Genetics
(D) Morphology

2. The transmission of characters or traits from one generation to the next is defined as:
(A) Variation
(B) Heredity
(C) Mutation
(D) Selection

3. The differences in traits among individuals of the same species are referred to as:
(A) Heredity
(B) Genetics
(C) Adaptation
(D) Variation

4. What term did Gregor Mendel use for the discrete units of inheritance that are passed down from parents to offspring?
(A) Factors
(B) Genes
(C) Chromosomes
(D) Alleles

5. An allele is best defined as:
(A) A distinct gene located on another chromosome
(B) The physical appearance exhibited by an organism
(C) An alternative form of a given gene
(D) A functional protein that controls a trait

6. If an organism possesses two identical alleles for a particular trait, its genotype is termed:
(A) Homozygous
(B) Heterozygous
(C) Hemizygous
(D) Co-dominant

7. The observable physical or biochemical characteristics of an organism, determined by both genetic makeup and environmental influences, constitute its:
(A) Genotype
(B) Karyotype
(C) Haplotype
(D) Phenotype

8. The genetic constitution of an organism in respect to a single trait or a set of traits is called its:
(A) Phenotype
(B) Genotype
(C) Pedigree
(D) Allele

9. Who among the following is universally recognised as the Father of Genetics?
(A) Sir Charles Darwin
(B) Thomas Hunt Morgan
(C) Gregor Mendel
(D) Hugo Marie de Vries

10. Match the genetic terms in List I with their descriptions in List II.
List I:
P. Gene
Q. Phenotype
R. Genotype
S. Homozygous
List II:
1. Physical expression of a trait
2. Identical alleles for a trait
3. Unit of inheritance
4. Genetic makeup of an organism
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-1, R-3, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-1, R-4, S-2

11. Which plant did Gregor Mendel use extensively for his foundational experiments in inheritance?
(A) Pisum sativum (Garden pea)
(B) Lathyrus odoratus (Sweet pea)
(C) Cicer arietinum (Chickpea)
(D) Zea mays (Maize)

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Volume, Velocity, and Variety. Volume describes the vast quantities of data generated continuously, Velocity signifies the high processing speed at which data is collected and analyzed, and Variety refers to the diverse structured, semi-structured, and unstructured data formats created across modern networks.

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24. Which of Mendel's laws is also commonly referred to as the "Law of Purity of Gametes"?
(A) Law of Dominance
(B) Law of Segregation
(C) Law of Independent Assortment
(D) Law of Linkage

25. The Law of Segregation is considered universally applicable because:
(A) All phenotypic traits strictly exhibit complete dominance in organisms
(B) Genes located on the same chromosome always remain linked together
(C) Alleles for a trait separate cleanly during gamete formation
(D) Multiple alternative alleles exist for every single genetic locus

26. Mendel's Law of Independent Assortment was formulated on the basis of results obtained from:
(A) Monohybrid crosses
(B) Test crosses
(C) Reciprocal crosses
(D) Dihybrid crosses

27. A genetic cross in which an organism with a dominant phenotype is crossed with a homozygous recessive individual is called a:
(A) Test cross
(B) Out cross
(C) Back cross
(D) Reciprocal cross

28. The primary purpose of performing a test cross is to determine the:
(A) Complete phenotypic expression of the F_1 hybrid generation
(B) Genotype of an individual exhibiting a dominant trait
(C) Exact physical distance and linkage between two target genes
(D) Frequency and overall mutation rate of a specific gene

29. If a heterozygous tall pea plant (Tt) is test crossed with a dwarf plant (tt), what is the expected phenotypic ratio of the offspring?
(A) 3:1
(B) 1:1
(C) 1:2:1
(D) All tall

30. Arrange the following steps of Mendel's hybridization experiment in the correct sequential order:
1. Self-pollination of F_1 plants to raise F_2 generation
2. Selection of true-breeding homozygous parents
3. Observation and statistical analysis of offspring
4. Emasculation and artificial cross-pollination of parents

(A) 2, 4, 1, 3
(B) 4, 2, 1, 3
(C) 2, 1, 4, 3
(D) 1, 2, 3, 4

31. The phenomenon where the F_1 hybrid exhibits a phenotype intermediate between the two homozygous parents is called:
(A) Co-dominance
(B) Multiple allelism
(C) Incomplete dominance
(D) Epistasis

32. In the snapdragon plant (Antirrhinum majus), crossing a red-flowered plant with a white-flowered plant yields pink F_1 plants. What is the phenotypic ratio in the F_2 generation?
(A) 3:1
(B) 9:3:3:1
(C) 1:1
(D) 1:2:1

33. Which of the following is the best example of co-dominance in humans?
(A) Skin colour inheritance
(B) Height variation
(C) ABO blood group type AB
(D) Eye colour

34. In co-dominance, the F_1 generation offspring:
(A) Resembles exactly one of the two parental phenotypes
(B) Expresses both parental traits fully and simultaneously
(C) Shows a distinct intermediate blend of both parental traits
(D) Fails to survive or complete embryonic development

35. Match the inheritance patterns in List I with their characteristic F_2 phenotypic ratios in List II.
List I:
P. Monohybrid complete dominance
Q. Dihybrid complete dominance
R. Monohybrid incomplete dominance

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S. Monohybrid test cross

List II:

1. 1:2:1
2. 3:1
3. 1:1
4. 9:3:3:1

(A) P-1, Q-4, R-2, S-3
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-4, R-1, S-3

36. The presence of more than two alternative forms of a gene occupying the same locus on a chromosome within a population is known as:
(A) Multiple alleles
(B) Polygenic inheritance
(C) Pleiotropy
(D) Co-dominance

37. Which human trait is a classic example of multiple alleles?
(A) Sickle cell anemia
(B) Hair colour
(C) ABO blood groups
(D) Phenylketonuria

38. How many different genotypes are possible for the ABO blood group system in humans?
(A) 3
(B) 4
(C) 6
(D) 8

39. A single gene controlling multiple phenotypic traits is known as:
(A) Polygenic inheritance
(B) Multiple allelism
(C) Epistasis
(D) Pleiotropy

40. Sickle cell anemia is an example of an inherited disorder caused by:
(A) An extra chromosome
(B) An autosomal recessive mutation
(C) An X-linked dominant gene
(D) A missing chromosome

41. Haemophilia is a genetic disorder that is primarily inherited as an:
(A) Autosomal dominant trait
(B) Autosomal recessive trait
(C) X-linked recessive trait
(D) Y-linked trait

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42. Colour blindness in humans is more common in males than in females because:
(A) The underlying mutated gene is located exclusively on the Y chromosome
(B) Male individuals naturally possess two functional X chromosomes per cell
(C) The disorder is inherited strictly as an autosomal dominant genetic trait
(D) It is an X-linked recessive trait, and males have only one X chromosome

43. In a standard human pedigree chart, a normal male is typically represented by a:
(A) Clear square
(B) Shaded circle
(C) Clear circle
(D) Shaded square

44. In a pedigree chart, what does a fully shaded symbol indicate?
(A) A heterozygous carrier carrying a recessive trait
(B) An individual affected by the specific trait
(C) A completely unaffected normal individual
(D) A deceased or non-viable individual

45. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Pedigree analysis is a crucial tool for studying the inheritance of genetic traits in humans.
Reason (R): Controlled cross-breeding experiments, as done in pea plants, cannot be performed in human populations.
In light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

46. The complete set of DNA, including all of its genes, present in a haploid set of chromosomes of an organism is called its:
(A) Genome
(B) Genotype
(C) Karyotype
(D) Phenotype

47. The specific physical location or position of a gene on a chromosome is referred to as its:

(A) Allele
(B) Centromere
(C) Locus
(D) Telomere

48. The final phenotype of an organism is the result of the interaction between its genotype and:
(A) Other species
(B) Completely random chance
(C) Its age only
(D) The environment

49. Genetic diversity within a population is primarily important because it:
(A) Ensures all individual organisms look completely identical to each other
(B) Significantly reduces the overall number of alleles present in a population
(C) Provides essential raw material for adaptation to changing environments
(D) Completely prevents evolutionary changes from occurring in the species

50. Select the correct sequence representing the hierarchy of genetic organization from smallest to largest:
(A) Gene, Nucleotide base pair, Chromosome, Genome
(B) Nucleotide base pair, Gene, Chromosome, Genome
(C) Genome, Chromosome, Gene, Nucleotide base pair
(D) Chromosome, Gene, Genome, Nucleotide base pair

51. Which of the following traits was considered DOMINANT in Mendel's experiments on pea plants?
(A) Wrinkled seed shape
(B) Green seed colour
(C) Dwarf stem height
(D) Axial flower position

52. Which of the following is a RECESSIVE trait in the garden pea plant according to Mendel?
(A) Yellow pod colour
(B) Round seed shape
(C) Yellow seed colour
(D) Green pod colour

53. In Mendelian genetics, the dwarf trait in pea plants is expressed only when the genotype is:
(A) TT
(B) Tt
(C) tt
(D) Both TT and Tt

54. The dominant flower colour in the pea plants studied by Mendel is:
(A) Violet
(B) White
(C) Yellow
(D) Red

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55. For the pod shape trait in pea plants, inflated is dominant. What is the recessive trait?
(A) Flat
(B) Wrinkled
(C) Narrow
(D) Constricted

56. The F_1 plants produced by crossing a pure tall pea plant and a pure dwarf pea plant were all tall. This observation led directly to the:
(A) Law of Segregation
(B) Law of Dominance
(C) Law of Independent Assortment
(D) Concept of Incomplete Dominance

57. In which year did Gregor Mendel formally publish his seminal work "Experiments on Plant Hybrids"?
(A) 1859
(B) 1865
(C) 1900
(D) 1953

58. Mendel's laws of inheritance remained unrecognised until they were independently rediscovered in the year 1900 by:
(A) Watson, Crick, and Wilkins
(B) Darwin, Wallace, and Lamarck
(C) Morgan, Sturtevant, and Bridges
(D) de Vries, Correns, and von Tschermak

59. While Mendel used pea plants, Thomas Hunt Morgan laid the foundation for the chromosomal theory of inheritance using which organism?
(A) Drosophila melanogaster
(B) Escherichia coli bacterial strains
(C) Laboratory mice (Mus musculus)
(D) Neurospora crassa pink bread mold

60. Match the pea plant traits in List I with their dominant forms in List II.
List I:
P. Seed shape
Q. Seed colour
R. Pod colour
S. Stem height

12. Which of the following was NOT a reason for Mendel selecting the pea plant for his experiments?
(A) It has a relatively short life cycle
(B) It requires a very long period to produce seeds
(C) It naturally exhibits self-pollination
(D) It possesses many easily observable contrasting traits

13. How many pairs of contrasting traits in the pea plant were studied by Gregor Mendel?
(A) 5 pairs
(B) 7 pairs
(C) 9 pairs
(D) 14 pairs

14. Which of the following traits was NOT one of the characteristics studied by Mendel in pea plants?
(A) Leaf size
(B) Flower colour
(C) Seed shape
(D) Stem height

15. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Mendel was highly successful in formulating the laws of inheritance compared to his predecessors.
Reason (R): Mendel applied statistical methods and mathematical logic to analyze the data from his breeding experiments.
In light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

16. The process of removing anthers from a bisexual flower before they mature, to prevent self-pollination, is known as:
(A) Bagging
(B) Hybridisation
(C) Mutation
(D) Emasculation

17. In a typical Mendelian monohybrid cross, what is the phenotypic ratio observed in the F_2 generation?
(A) 1:2:1
(B) 9:3:3:1
(C) 3:1
(D) 2:1

18. What is the genotypic ratio of the F_2 generation in a Mendelian monohybrid cross?
(A) 3:1
(B) 1:2:1
(C) 1:1:1:1
(D) 9:3:3:1

19. The graphical representation used to calculate the probability of all possible genotypes of offspring in a genetic cross was developed by:
(A) Gregor Johann Mendel
(B) William Bateson
(C) Wilhelm Ludwig Johannsen
(D) Reginald Punnett

20. Consider the following statements regarding true-breeding plants in Mendel's experiments:
I. A true-breeding line shows the stable trait inheritance for several generations.
II. True-breeding lines are produced through continuous cross-pollination.
III. Mendel selected 14 true-breeding pea plant varieties as pairs.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

21. A breeding experiment that tracks the inheritance of two different traits simultaneously is called a:
(A) Monohybrid cross
(B) Test cross
(C) Dihybrid cross
(D) Back cross

22. What is the classic phenotypic ratio expected in the F_2 generation of a Mendelian dihybrid cross?
(A) 9:3:3:1
(B) 3:1
(C) 1:2:1
(D) 1:1:1:1

23. Mendel's Law of Dominance states that in a heterozygous individual:
(A) Both alleles blend to produce a new phenotype
(B) Both inherited alleles are expressed equally
(C) Neither allele is inherited by the offspring
(D) Only one allele is expressed

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(D) 16

72. An organism with the genotype AABB will produce gametes of how many genotypic types?
(A) 1 type
(B) 2 types
(C) 4 types
(D) 8 types

73. The Punnett square provides a visual method for determining the:
(A) Exact number of functional chromosomes present in an individual organism
(B) Precise natural lifespan and survival rate of the resulting offspring
(C) Probability of all potential offspring genotypes resulting from a cross
(D) Frequency and rate of spontaneous gene mutation in a target chromosome

74. In a standard dihybrid cross between two heterozygotes (AaBb × AaBb), how many squares are required in the Punnett square to show all possible zygote combinations?
(A) 4
(B) 8
(C) 16
(D) 32

75. Match the scientists in List I with their contribution in List II.
List I:
P. Gregor Mendel
Q. Reginald Punnett
R. Wilhelm Johannsen
S. William Bateson
List II:
1. Coined the term 'Genetics'
2. Laws of Inheritance
3. Checkerboard method for crosses
4. Coined the term 'Gene'
(A) P-2, Q-3, R-4, S-1
(B) P-2, Q-4, R-3, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-2, R-1, S-4

76. Traits in humans such as height and skin colour, which show a continuous range of variation and are controlled by three or more genes, are examples of:
(A) Multiple allelism
(B) Polygenic inheritance
(C) Pleiotropy
(D) Incomplete dominance

77. The condition in which a single gene mutation results in multiple phenotypic effects in an organism is known as:
(A) Epistasis
(B) Pleiotropy
(C) Co-dominance
(D) Polygenic inheritance

78. In pea plants, the gene controlling seed shape also happens to control the size of starch grains synthesised in the seed. This is an example of:
(A) Pleiotropy
(B) Incomplete dominance
(C) Multiple alleles
(D) Sex linkage

79. Co-dominance differs fundamentally from incomplete dominance because in co-dominance:
(A) Only the dominant allele is phenotypically expressed in heterozygous individuals
(B) Two alleles completely blend together to generate an intermediate phenotypic trait
(C) Both alleles express themselves fully and independently in a heterozygous organism
(D) One allele completely suppresses the phenotypic expression of an unlinked gene

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80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Law of Independent Assortment holds absolutely true for all pairs of genes in an organism.
Reason (R): Genes located very close to each other on the same chromosome are linked and tend to be inherited together.
In light of the above statements, choose the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

81. In human beings, the primary mechanism of sex determination relies on:
(A) Environmental temperature during fetal development
(B) The ratio of autosomes to chromosomes
(C) The XX-XY sex chromosome system
(D) The ZW-ZZ sex chromosome system

List II:
1. Green
2. Yellow
3. Tall
4. Round

(A) P-4, Q-1, R-2, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-4, R-3, S-1
(D) P-1, Q-2, R-4, S-3

61. The mathematical equation $p^2 + 2pq + q^2 = 1$, which describes the genetic stability of a population under ideal conditions, is known as the:
(A) Mendelian equation
(B) Hardy-Weinberg principle
(C) Punnett square formula
(D) Chromosomal mapping equation

62. Which of the following is a direct application of genetics in agriculture?
(A) High-yielding and disease-resistant crop development
(B) Large-scale production and application of synthetic fertilizers
(C) Construction of advanced and efficient irrigation canals
(D) Widespread adoption of traditional organic farming techniques

63. The primary goal of genetic counseling in medicine is to:
(A) Treat and cure acute viral infections through prescribed modern antibiotics
(B) Permanently modify or change the hereditary blood type of an individual patient
(C) Assess risk and educate families regarding inherited genetic disorders
(D) Prescribe personalized dietary and nutrition charts for body weight loss

64. The process of intentionally exposing seeds to chemicals or radiation in order to generate beneficial genetic variations for agriculture is called:
(A) Natural selection
(B) Emasculation
(C) Pedigree analysis
(D) Mutation breeding

65. Consider the following statements regarding Mendel's Law of Segregation:
I. It states that alleles of a gene do not blend.
II. Gametes receive only one of the two alleles for a trait, making them pure.
III. It is an exception to normal inheritance and only applies to dihybrid crosses.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

66. When two homozygous parents with contrasting traits are crossed, the genotype of the F_1 generation is always:
(A) Homozygous dominant
(B) Heterozygous
(C) Homozygous recessive
(D) Mutated

67. A trait that reappears in the F_2 generation after being hidden in the F_1 generation is described as:
(A) Dominant
(B) Co-dominant
(C) Lethal
(D) Recessive

68. A genetic cross that involves reversing the sexes of the parents relative to a previous cross (e.g., crossing a tall female with a dwarf male, then a dwarf female with a tall male) is known as a:
(A) Reciprocal cross
(B) Standard test cross
(C) Mendelian dihybrid cross
(D) Classical back cross

69. Crossing an F_1 hybrid individual with either of its pure-breeding parents is technically called a:
(A) Monohybrid cross
(B) Mutation cross
(C) Back cross
(D) Segregation cross

70. Is every test cross considered a back cross?
(A) Yes, crossing F_1 with the recessive parent is a form of back cross
(B) No, test crosses and back crosses represent completely unrelated genetic crosses
(C) Only when performing dihybrid crosses involving two distinct genetic traits
(D) Only in animal breeding experiments, never in plant genetics studies

71. How many different types of gametes can an individual with the genotype AaBb produce?
(A) 2
(B) 4
(C) 8

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(D) Aneuploidy

94. Monozygotic (identical) twins possess the exact same:
(A) Genotype
(B) Fingerprints
(C) Epigenetic tags
(D) Environmental experiences

95. Select the correct sequence representing a typical Mendelian breeding experiment across generations:
(A) F_1 generation → P generation → Gametes → F_2 generation
(B) P generation → Gametes → F_1 generation → F_2 generation
(C) P generation → F_2 generation → Gametes → F_1 generation
(D) Gametes → F_2 generation → F_1 generation → P generation

96. Phenylketonuria (PKU) is an inherited metabolic disorder. What is its mode of inheritance?
(A) Autosomal dominant
(B) X-linked dominant
(C) Y-linked
(D) Autosomal recessive

97. Turner syndrome is a chromosomal disorder in females characterised by the absence of one X chromosome. The karyotype is written as:
(A) 47, XXY
(B) 47, XXX
(C) 45, X_0
(D) 46, XY

98. A male individual displaying feminine characteristics, sterile nature, and possessing a 47, XXY karyotype is diagnosed with:
(A) Down syndrome
(B) Klinefelter syndrome
(C) Turner syndrome
(D) Patau syndrome

99. Cystic fibrosis is a genetic disorder affecting the respiratory and digestive systems. It is inherited as an:
(A) Autosomal dominant trait
(B) X-linked recessive trait
(C) X-linked dominant trait
(D) Autosomal recessive trait

100. Match the genetic disorders in List I with their cause/inheritance type in List II.
List I:
P. Down Syndrome
Q. Haemophilia
R. Sickle cell anemia
S. Turner Syndrome
List II:
1. X-linked recessive
2. Trisomy 21
3. Monosomy X (45, X_0)
4. Autosomal recessive mutation
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

101. The phenomenon where the expression of one gene masks or interferes with the expression of another completely different gene is termed:
(A) Dominance
(B) Pleiotropy
(C) Epistasis
(D) Co-dominance

102. Genes that, when expressed in a homozygous state, cause the death of the organism are known as:
(A) Lethal genes
(B) Dominant genes
(C) Polygenes
(D) Complementary genes

103. In complementary gene interaction, two independent non-allelic genes must both be present in dominant form to produce a specific phenotype. This changes the standard 9:3:3:1 ratio to:
(A) 12:3:1
(B) 15:1
(C) 9:3:4
(D) 9:7

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104. Quantitative inheritance is another term used to describe:
(A) Multiple allelism
(B) Polygenic inheritance
(C) Maternal inheritance
(D) Epistasis

105. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A test cross is used to determine the exact genotype of an organism displaying a dominant phenotype.
Reason (R): The dominant organism is crossed

63. (C) Assess risk and educate families regarding inherited genetic disorders
Genetic counseling is a specialized medical service aimed at assessing familial risks of inherited conditions. Healthcare professionals evaluate family pedigrees, interpret genetic test results, explain inheritance patterns, and guide individuals regarding potential disease transmission, helping families make informed medical, personal, and reproductive decisions for their futures.

64. (D) Mutation breeding
Mutation breeding involves exposing seeds or plant tissues to chemical mutagens or ionizing radiation to induce novel genetic variations artificially. Breeders screen mutated populations to select desirable agricultural traits, such as disease resistance or higher yield, which are then systematically bred into commercial crop varieties for farming.

65. (A) I and II only
The Law of Segregation dictates that alleles for a gene separate cleanly without blending, ensuring gametes carry only one allele. This fundamental law is universal across diploid organisms and applies to monohybrid and dihybrid inheritance alike, making claims of non-blending and gamete purity entirely correct in genetics.

66. (B) Heterozygous
Crossing two homozygous parent organisms exhibiting contrasting traits produces F_1 offspring that are invariably heterozygous. The progeny inherit one dominant allele from one parent and one recessive allele from the other parent, establishing a uniform heterozygous genotype across the entire first filial generation in Mendelian crosses.

67. (D) Recessive
A recessive trait remains unexpressed in heterozygous F_1 individuals because it is masked by a dominant allele. However, when F_1 plants are self-pollinated, the recessive alleles segregate during gamete formation and recombine in the F_2 generation, allowing the hidden recessive phenotype to reappear in homozygous individuals.

68. (A) Reciprocal cross
A reciprocal cross involves two separate breeding experiments where the sexes of the parents associated with specific phenotypes are reversed. For instance, crossing a tall female with a dwarf male, followed by crossing a dwarf female with a tall male, determines if a trait is autosomal or sex-linked.

69. (C) Back cross
A back cross is a genetic cross where an F_1 hybrid is mated with either of its pure-breeding parental genotypes, whether dominant or recessive. This classic technique allows geneticists to isolate specific parental characteristics or analyze allele transmission patterns within experimental plant and animal breeding programs effectively.

70. (A) Yes, crossing F_1 with the recessive parent is a form of back cross
Every test cross qualifies as a specialized back cross because it involves crossing an F_1 individual with the homozygous recessive parent genotype. While all test crosses are back crosses, back crosses also include matings with homozygous dominant parents, making the classification statement completely accurate in classical genetics.

71. (B) 4
An individual with the heterozygous genotype AaBb carries two independently assorting gene pairs. Applying the formula 2^n, where n equals the number of heterozygous loci ($2^2 = 4$), reveals that four distinct gametic allele combinations are produced in equal frequencies: AB, Ab, aB, and ab.

72. (A) 1 type
An organism possessing the completely homozygous genotype AABB produces only one genotypic type of gamete, containing the alleles AB. Because no heterozygous loci exist at either gene position, all meiotic divisions yield identical haploid gametes carrying dominant alleles for both genes without any genetic variation.

73. (C) Probability of all potential offspring genotypes resulting from a cross
A Punnett square serves as a predictive mathematical model used in genetics to determine the relative probabilities of all potential offspring genotypes. By combining male and female gametes systematically along grid axes, it calculates expected genotypic and phenotypic ratios resulting from defined parental crosses in biological organisms.

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116. Arrange the following genetic structures in increasing order of their physical complexity (simplest to most complex):
1. Nucleotide
2. Gene
3. Chromosome
4. Nucleus

(A) 2, 1, 3, 4
(B) 1, 2, 3, 4
(C) 1, 3, 2, 4
(D) 4, 3, 2, 1

117. Genes located on the same chromosome that tend to be inherited together and do not strictly follow the Law of Independent Assortment are called:
(A) Epistatic genes
(B) Pleiotropic genes
(C) Linked genes
(D) Complementary genes

118. Match the Mendelian ratios in List I with their corresponding cross type in List II.

List I:
P. 3:1
Q. 1:2:1
R. 9:3:3:1
S. 1:1

List II:
1. Dihybrid F_2 phenotypic ratio
2. Monohybrid test cross ratio
3. Monohybrid F_2 phenotypic ratio
4. Monohybrid F_2 genotypic ratio

(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

119. Consider the following statements regarding non-Mendelian inheritance:
I. In co-dominance, both alleles are fully and equally expressed in the heterozygote.
II. In incomplete dominance, a blending effect is seen, creating an intermediate phenotype.
III. The human blood group AB is a classic example of incomplete dominance.

Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

120. Ultimately, the entire study of Mendelian laws, the use of the Punnett square, and the analysis of heredity and variation are consolidated under the biological discipline of:
(A) Physiology
(B) Genetics
(C) Anatomy
(D) Taxonomy

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20. (C) I and III only
True-breeding plant lines undergo continuous self-pollination to achieve homozygous genotypes that consistently express stable traits across generations. Mendel selected fourteen true-breeding varieties representing seven pairs of contrasting characters. Cross-pollination breaks true-breeding lines rather than producing them, making continuous selfing necessary for genetic stability.

21. (C) Dihybrid cross
A dihybrid cross is a specific genetic breeding experiment designed to analyze the simultaneous inheritance of two distinct, non-allelic traits controlled by different gene pairs. By following two contrasting character pairs across generations, researchers can evaluate whether individual genes segregate independently or remain associated together during gamete formation.

22. (A) 9:3:3:1
In a standard Mendelian dihybrid cross involving two fully dominant traits, crossing double heterozygotes produces an F_2 phenotypic ratio of 9:3:3:1. This distribution yields nine double dominant, three dominant-recessive combinations of each type, and one double recessive offspring, demonstrating independent assortment of separate gene pairs.

23. (D) Only one allele is expressed
The Law of Dominance states that when two contrasting alleles for a specific trait are brought together in a heterozygous individual, only one allele is phenotypically expressed. The expressed allele is termed dominant, whereas the masked allele remains present without expression and is designated as recessive.

24. (B) Law of Segregation
The Law of Segregation is widely known as the Law of Purity of Gametes. This fundamental principle states that paired alleles residing together in a diploid organism separate cleanly during meiosis, ensuring that each resulting haploid gamete receives only one allele and remains completely pure regarding that specific trait.

25. (C) Alleles for a trait separate cleanly during gamete formation
The Law of Segregation is universally applicable across diploid organisms because homologous chromosomes separate during meiotic cell division without blending or modifying their constituent alleles. Regardless of phenotypic dominance variations or environmental influences, alleles segregate into distinct gametes during gametogenesis, maintaining their individual structural and genetic integrity.

26. (D) Dihybrid crosses
Mendel formulated the Law of Independent Assortment through quantitative observations of dihybrid crosses. By tracking two distinct traits simultaneously, he demonstrated that the segregation of one allele pair occurs completely independently of the segregation of another allele pair located on different chromosomes during gamete formation.

27. (A) Test cross
A test cross involves mating an individual displaying a dominant phenotype with a homozygous recessive individual. Because the recessive parent contributes only recessive alleles to offspring, the resulting phenotypic distribution directly reveals whether the dominant parent is homozygous dominant or heterozygous for the gene under investigation.

28. (B) Genotype of an individual exhibiting a dominant trait
The primary purpose of conducting a test cross is to uncover the unknown genotype of an organism exhibiting a dominant phenotype. Crossing the dominant organism with a homozygous recessive partner yields offspring whose phenotypic ratios immediately distinguish between a homozygous dominant genotype and a heterozygous genotype.

29. (B) 1:1
A test cross between a heterozygous tall plant (Tt) and a dwarf plant (tt) yields offspring in a 1:1 ratio. Half of the resulting progeny receive the dominant allele and exhibit the tall phenotype, while the remaining half inherit recessive alleles from both parents, manifesting the dwarf phenotype.

30. (A) 2, 4, 1, 3
Mendelian hybridization follows a precise sequence beginning with selecting true-breeding

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10. (D) P-3, Q-1, R-4, S-2
In classical genetics, a gene functions as the discrete unit of inheritance transmitting traits. Phenotype describes the visible physical expression of traits, whereas genotype denotes the underlying genetic makeup. Homozygous specifies the presence of identical alleles at a given locus, establishing a clear link between structural terminology and biological functions.

11. (A) Pisum sativum (Garden pea)
Gregor Mendel conducted his classical genetics experiments using the garden pea, scientific name Pisum sativum. This plant species was chosen because it possesses distinct contrasting characters, self-pollinates naturally, undergoes controlled artificial cross-pollination easily, and yields a large number of offspring within a short lifecycle under simple garden culture.

12. (B) It requires a very long period to produce seeds
Garden pea plants were ideal experimental organisms for genetic crosses because they possess a relatively short annual lifecycle and produce seeds rapidly. A prolonged period for seed production would have severely hindered experimental progress, making rapid generation turnover essential for gathering quantitative statistical data across successive plant generations.

13. (B) 7 pairs
Gregor Mendel selected and analyzed seven distinct pairs of contrasting traits in garden pea plants during his inheritance studies. These character pairs included stem height, flower position, flower colour, pod shape, pod colour, seed shape, and seed colour, each showing clear dominant and recessive forms without intermediate expression patterns.

14. (A) Leaf size
Leaf size was not among the seven contrasting character pairs investigated by Mendel in garden pea plants. Mendel focused specifically on clearly distinguishable features, such as seed shape, seed colour, pod shape, pod colour, flower position, flower colour, and stem height, ensuring unambiguous quantitative analysis of inheritance patterns.

15. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Mendel succeeded where earlier hybridization researchers failed because he integrated rigorous mathematical logic, probability theory, and large-scale statistical sampling into biological experimentation. Analyzing large offspring sample sizes allowed him to formulate precise numerical ratios and establish predictive laws of inheritance, providing scientific validity to his groundbreaking conclusions.

16. (D) Emasculation
Emasculation is the surgical or manual removal of anthers from bisexual flower buds before pollen maturation and dehiscence. This crucial procedure prevents unwanted self-pollination in experimental plant breeding, allowing researchers to perform controlled cross-pollination using selected pollen grains from desired male parent plants to generate specific hybrid progeny.

17. (C) 3:1
In a classic Mendelian monohybrid cross involving complete dominance, self-pollination of heterozygous F_1 individuals yields an F_2 generation displaying a 3:1 phenotypic ratio. Three-fourths of the offspring express the dominant phenotypic character, whereas one-fourth exhibit the recessive phenotypic character due to allele segregation during gamete formation.

18. (B) 1:2:1
The genotypic ratio of the F_2 generation in a Mendelian monohybrid cross is 1:2:1. Among the progeny, one-fourth are homozygous dominant, one-half are heterozygous dominant carrying both alleles, and one-fourth are homozygous recessive, reflecting the random combination of male and female gametes during fertilization events.

19. (D) Reginald Punnett
The Punnett square was invented by British geneticist Reginald C. Punnett. It provides a structured visual diagram and checkerboard matrix that calculates all potential gametic combinations, genotype probabilities, and resulting phenotypic frequencies expected among offspring derived from controlled genetic crosses between organisms of known parental genotypes.

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ANSWERS

1. (C) Genetics
Genetics is the fundamental branch of biological science that investigates how traits and genetic information are passed from parents to progeny, alongside studying the natural differences occurring among individuals of a species. It systematically analyzes hereditary mechanisms, gene structures, patterns of variation, and the biological principles governing inheritance across generations of living organisms.

2. (B) Heredity
Heredity refers to the biological process through which structural, physiological, and functional characteristics are transmitted from parent organisms to their offspring during reproduction. This continuity of biological traits across consecutive generations ensures species stability, preserving core parental genetic information while allowing subtle variations to accumulate across lineages over evolutionary timeframes.

3. (D) Variation
Variation encompasses the observable physical, physiological, and genetic differences present among individual organisms belonging to the same biological species. These morphological and genetic disparities arise through mechanisms like sexual recombination, gene mutations, and environmental interactions during development, providing the necessary material for natural selection to act upon within populations over time.

4. (A) Factors
Gregor Mendel postulated that physical inheritance is governed by particulate units passed unaltered from parents to offspring through gametes. Before the modern discovery and characterization of DNA and genes, these fundamental functional units of biological inheritance were historically identified and referred to as factors, which maintain structural integrity across generations.

5. (C) An alternative form of a given gene
An allele represents a specific functional variant or alternative molecular form of a single gene locus situated at a given chromosomal position. Different alleles of the same gene possess distinct nucleotide sequences, which code for modified proteins that ultimately influence contrasting phenotypic traits or physiological expressions within organisms.

6. (A) Homozygous
An organism is defined as homozygous for a specific genetic locus when it possesses two structurally identical alleles on its homologous chromosomes. This genetic state ensures that the organism breeds true for that particular trait, producing uniform gametes that carry only one identical version of the allele during sexual reproduction.

7. (D) Phenotype
The phenotype represents the observable physical, physiological, anatomical, and biochemical characteristics displayed by an organism throughout its lifecycle. It is dynamically produced through the continuous interaction between an organism's underlying genetic constitution and surrounding environmental conditions, resulting in the actual physical traits, traits expression, and functional capabilities observed externally.

8. (B) Genotype
Genotype describes the complete underlying genetic constitution and precise allelic composition of an organism at a given locus or set of loci. Unlike visible physical traits, the genotype represents the inherited nucleotide code within the genome, determining potential phenotypic expression, inheritance patterns, and transmission of genetic material to progeny.

9. (C) Gregor Mendel
Gregor Mendel is universally recognized as the Father of Genetics due to his pioneering hybridization experiments with garden peas. His systematic application of quantitative statistical methods led to the formulation of fundamental laws governing inheritance, establishing the foundational concepts of particulate hereditary units that revolutionized biological understanding of heredity.

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parents. Anthers are removed via emasculation to enable controlled artificial cross-pollination. The resulting F_1 progeny are self-pollinated to raise the F_2 generation, after which offspring phenotypes and genotypes are recorded for statistical evaluation and detailed genetic analysis.

31. (C) Incomplete dominance
Incomplete dominance occurs when neither allele at a locus is completely dominant over the other in a heterozygous individual. Consequently, the F_1 hybrid develops an intermediate phenotype blending traits from both homozygous parents, producing a distinct physical appearance distinct from either original parental type.

32. (D) 1:2:1
In snapdragon flowers, incomplete dominance causes heterozygous F_1 plants to express pink flowers when red and white parents are crossed. Selfing these pink hybrids produces an F_2 generation with red, pink, and white flowers in a 1:2:1 phenotypic ratio, perfectly matching the underlying 1:2:1 genotypic distribution.

33. (C) ABO blood group type AB
The human ABO blood group system demonstrates co-dominance through the AB blood type. Individuals possessing both IA and IB alleles produce both A and B surface carbohydrates on their red blood cells simultaneously, expressing both parental traits fully without blending or dominance suppression of one allele over the other.

34. (B) Expresses both parental traits fully and simultaneously
In co-dominance, heterozygous offspring express both parental alleles completely and simultaneously in their phenotype. Neither allele suppresses or masks the other, nor do they blend to form an intermediate trait. Instead, both parental characters are fully detectable and functionally active within the individual organism.

35. (D) P-2, Q-4, R-1, S-3
Monohybrid crosses with complete dominance produce a 3:1 F_2 phenotypic ratio, whereas dihybrid crosses yield a 9:3:3:1 ratio. Incomplete dominance alters the monohybrid phenotypic ratio to 1:2:1, matching its genotypic ratio. A monohybrid test cross results in a 1:1 phenotypic distribution among the resulting offspring.

36. (A) Multiple alleles
Multiple allelism describes a condition where more than two alternative allelic forms of a single gene locus exist within a biological population. Although an individual diploid organism carries only two alleles, the presence of multiple alleles across a population increases genetic diversity and phenotypic trait variations.

37. (C) ABO blood groups
The human ABO blood group system is a classic example of multiple allelism, controlled by three distinct alleles designated IA, IB, and i situated at a single gene locus. These alleles govern red blood cell surface antigens, resulting in four distinct blood phenotypes within human populations.

38. (C) 6
The ABO blood group system in humans involves three distinct alleles, yielding six possible diploid genotypes. Combinations of these three alleles produce homozygous IAIA, IBIB, and ii, alongside heterozygous IAi, IBi, and IAIB genotypes, which collectively determine the four standard ABO blood types in human populations.

39. (D) Pleiotropy
Pleiotropy is a genetic phenomenon wherein a single gene influences multiple, seemingly unrelated phenotypic traits across an organism. A single biochemical pathway disruption caused by a gene mutation can lead to varied physiological, anatomical, and developmental defects throughout different tissue systems within the body structure.

40. (B) An autosomal recessive mutation
Sickle cell anemia is an inherited blood disorder caused by an autosomal recessive point mutation in the beta-globin gene. Individuals carrying two mutated alleles produce abnormal hemoglobin, causing red blood cells to assume a sickle shape under low oxygen conditions, leading to hemolytic anemia and vascular occlusion.

41. (C) X-linked recessive trait
Haemophilia is a sex-linked recessive disorder transmitted via the X chromosome. Because the defective gene resides on the X chromosome, male individuals possessing a single mutated

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copy develop the disease, which impairs the blood clotting cascade and leads to prolonged, excessive bleeding following minor tissue injuries.

42. (D) It is an X-linked recessive trait, and males have only one X chromosome
Colour blindness is an X-linked recessive genetic condition. Males possess a single X chromosome paired with a Y chromosome, meaning a single mutated allele on their X chromosome directly manifests the trait. Females require two mutated X chromosomes to express colour blindness, making the condition significantly less common in females.

43. (A) Clear square
In human pedigree charts, biological males are consistently represented by square symbols, whereas females are represented by circles. An unshaded or clear square specifically denotes a normal male individual who does not exhibit the genetic condition or inherited trait under investigation within the analyzed family pedigree lineage.

44. (B) An individual affected by the specific trait
Pedigree diagrams utilize standardized geometric symbols to map inheritance patterns across family generations. A fully shaded symbol indicates an individual who is affected by the specific genetic trait or clinical disorder under study, distinguishing affected individuals from unshaded unaffected individuals and partially shaded heterozygous carrier individuals.

45. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Pedigree analysis serves as an indispensable tool in human genetics because controlled experimental breeding crosses cannot be ethically or practically performed on human subjects. Constructing multi-generational family trees allows geneticists to apply Mendelian principles, trace inheritance modes, identify carriers, and calculate recurrence risks for inherited disorders.

46. (A) Genome
A genome encompasses the complete set of genetic material, including all functional genes and non-coding DNA sequences, contained within a single haploid set of chromosomes of an organism. It provides the total biological instructions necessary for constructing, maintaining, and operating an organism throughout its complete lifecycle.

47. (C) Locus
A gene locus refers to the specific physical location occupied by a gene or allele on a chromosome. Homologous chromosomes possess identical loci, where corresponding alleles reside at matching structural positions, allowing predictable alignment, genetic recombination, and orderly segregation during meiotic cell division in reproductive organs.

48. (D) The environment
An organism's final phenotype is determined through complex interactions between its inherited genotype and surrounding environmental factors. While the genotype sets the overall developmental potential, environmental variables such as temperature, nutrition, light, and stress modulate gene expression levels, altering the final physical and functional outcome.

49. (C) Provides essential raw material for adaptation to changing environments
Genetic diversity provides crucial biological variation within natural populations, supplying the essential raw material required for species to adapt to shifting environmental conditions. High genetic variability increases population resilience, enabling survival against emerging pathogens, climate changes, and environmental disturbances through natural selection mechanisms over time.

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50. (B) Nucleotide base pair, Gene, Chromosome, Genome
The spatial hierarchy of genetic structures begins with individual nucleotide base pairs, which join to form functional gene segments. Multiple genes arrange sequentially along linear DNA molecules wrapped into chromosomes, and the total collection of all chromosomes constitutes the complete hereditary blueprint known as the genome.

51. (D) Axial flower position
In Mendel's pea plant experiments, axial flower position was identified as a dominant trait over terminal flower position. Plants carrying at least one dominant allele produce flowers along the main stem nodes, whereas homozygous recessive plants develop flowers concentrated exclusively at the tips of the stems.

52. (A) Yellow pod colour
Yellow pod colour represents a recessive trait in garden pea plants, whereas green pod colour is dominant. A pea plant produces yellow pods only when it inherits two copies of the recessive allele, ensuring that heterozygous plants express green pods due to masking by the dominant allele.

53. (C) tt
Dwarf stem height in garden pea plants is a completely recessive trait governed by a single gene pair. The dwarf phenotype is expressed exclusively when an individual possesses two recessive alleles (tt). The presence of even a single dominant allele (T) results in tall stem growth.

54. (A) Violet
Violet flower colour is the dominant phenotypic trait in garden pea plants studied by Gregor Mendel, whereas white flower colour is recessive. Heterozygous plants carrying one violet allele and one white allele consistently produce violet flowers, concealing the white phenotype in full accordance with Mendelian principles of dominance.

55. (D) Constricted
For pod shape in garden pea plants, inflated pods represent the dominant phenotype, whereas constricted pods represent the recessive trait. Constricted pods appear narrow and tightly contoured around individual seeds, expressing themselves only when the plant is homozygous for the recessive pod shape allele within its genome.

56. (B) Law of Dominance
When pure-breeding tall and dwarf pea plants are crossed, all F_1 hybrid progeny display tall stems. The complete absence of dwarf plants in the first filial generation demonstrated that one trait masks another, establishing the foundational principles of Mendel's Law of Dominance in monohybrid genetic inheritance.

57. (B) 1865
Gregor Mendel formally presented his research findings to the Natural History Society of Brünn in 1865 and published his paper, "Experiments on Plant Hybrids," in 1866. This seminal publication outlined the fundamental principles governing particulate inheritance, laying the primary foundation for modern genetic science as a whole.

58. (D) de Vries, Correns, and von Tschermak
Mendel's groundbreaking work remained neglected for thirty-five years until 1900, when three scientists independently rediscovered his principles. Hugo de Vries in Holland, Carl Correns in Germany, and Erich von Tschermak in Austria conducted separate plant breeding experiments, confirming Mendel's rules of inheritance and initiating modern genetics.

59. (A) Drosophila melanogaster
Thomas Hunt Morgan selected the fruit fly, Drosophila melanogaster, for extensive genetic investigations. Drosophila offered major advantages including a brief two-week lifecycle, high reproductive output, simple laboratory culture, and clear sexual dimorphism, allowing Morgan to establish the chromosomal theory of inheritance and sex-linked traits.

60. (B) P-4, Q-2, R-1, S-3
In garden peas, round seed shape, yellow seed colour, green pod colour, and tall stem height represent dominant traits. Wrinkled seeds, green seeds, yellow pods, and dwarf stems are their corresponding recessive forms. Matching these characters connects each trait to its specific dominant phenotype identified by Mendel.

61. (B) Hardy-Weinberg principle
The Hardy-Weinberg principle provides a mathematical model, $p^2 + 2pq + q^2 = 1$, expressing allele and genotype frequencies in an ideal non-evolving population. It demonstrates that genetic variation remains constant across generations unless perturbed by factors such as mutation, migration, natural selection, or non-random mating.

62. (A) High-yielding and disease-resistant crop development
Application of genetic principles in agriculture has enabled the creation of high-yielding, disease-resistant, and climate-resilient crop varieties through selective breeding and modern biotechnology. These genetic advances significantly increase global food production, enhance nutritional content, and protect crops against destructive environmental pathogens and severe climatic conditions.

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with a homozygous recessive parent, so the offspring's phenotypes reveal the hidden recessive alleles.

In light of the above statements, choose the correct answer from the options given below:

(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

106. In the context of modern genetics and agriculture, GMO stands for:
(A) Genetically Maintained Organ Structure
(B) Generally Modified Biological Organism
(C) Genetic Mutation Order and Classification
(D) Genetically Modified Organism

107. Bt Cotton is an example of applied genetics. It is genetically modified to be:
(A) Resistant to bollworm insect pests
(B) Highly resistant to extreme drought conditions
(C) Exceptionally rich in dietary Vitamin A
(D) Fully capable of fixing atmospheric nitrogen directly

108. Golden rice is a genetically modified variety of rice created as an application of genetics in medicine/nutrition to combat the deficiency of:
(A) Vitamin C
(B) Vitamin A
(C) Iron
(D) Calcium

109. The modern branch of genetics that studies how an individual's genetic makeup affects their body's response to therapeutic drugs is known as:
(A) Epigenetics
(B) Pharmacogenomics
(C) Eugenics
(D) Euthenics

110. Match the applications of genetics in List I with their descriptions in List II.

List I:
P. Bt Cotton
Q. Golden Rice
R. Gene Therapy
S. Genetic Counseling

List II:
1. Correcting defective genes in humans
2. Insect-resistant crop
3. Advising on inherited disorder risks
4. Vitamin A enriched crop

(A) P-2, Q-4, R-1, S-3
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-1, Q-3, R-2, S-4

111. If a pea plant with the heterozygous genotype Tt is self-pollinated, what percentage of the offspring is expected to be dwarf (tt)?
(A) 0%
(B) 25%
(C) 50%
(D) 75%

112. In a Mendelian dihybrid cross involving two heterozygous parents (AaBb x AaBb), what proportion of the F_2 offspring will be completely homozygous recessive (aabb)?
(A) 9/16
(B) 3/16
(C) 4/16
(D) 1/16

113. The physical and chemical basis of heredity in living organisms is the:
(A) Structural and functional protein molecule
(B) Cytoplasmic protein-synthesizing ribosome
(C) Chromosomal DNA molecule
(D) Selectively permeable cell membrane

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114. Genetic variation is considered fundamentally essential for the long-term process of:
(A) Mitosis
(B) Evolution
(C) Digestion
(D) Respiration

115. Consider the following statements regarding the reasons for Mendel's success:
I. He studied the inheritance of only one or two contrasting traits at a time.
II. He kept precise mathematical and statistical records of all his crosses.
III. He chose traits that were linked closely on the same chromosome.

Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

74. (C) 16
A dihybrid cross between two heterozygous parents (AaBb × AaBb) requires a four-by-four grid containing sixteen individual squares. Each parent produces four distinct types of gametes, and multiplying these parental combinations (4 × 4) generates sixteen total zygotic possibilities within the Punnett square matrix layout.

75. (A) P-2, Q-3, R-4, S-1
Mendel formulated the basic laws of inheritance, and Punnett introduced the checkerboard method for analyzing genetic crosses. Wilhelm Johannsen coined the term gene to describe hereditary units, while William Bateson coined the umbrella term genetics, establishing foundational terminology and analytical tools in biological science research.

76. (B) Polygenic inheritance
Polygenic inheritance occurs when a single phenotypic trait is controlled by the cumulative action of multiple independent genes. Human traits such as height and skin colour demonstrate polygenic inheritance, exhibiting a continuous spectrum of phenotypic variations rather than distinct, discrete Mendelian phenotypic categories in human populations.

77. (B) Pleiotropy
Pleiotropy is a genetic phenomenon where a single mutated gene influences multiple, diverse phenotypic traits within an organism. A single gene defect can affect various physiological pathways, leading to distinct clinical manifestations across multiple anatomical systems, as seen in complex human disorders like sickle cell anemia.

78. (A) Pleiotropy
In garden peas, the gene governing seed shape also regulates starch grain synthesis within seeds. Homozygous round seeds synthesize large starch grains, heterozygous seeds produce intermediate-sized grains, and wrinkled seeds make small grains, demonstrating pleiotropy where one gene controls seed texture and starch granule size simultaneously.

79. (C) Both alleles express themselves fully and independently in a heterozygous organism
Co-dominance differs fundamentally from incomplete dominance because heterozygous individuals express both parental alleles fully and independently without blending. In contrast, incomplete dominance results in an intermediate phenotype where neither allele is fully expressed, generating a blended physical appearance distinct from both homozygous parents in genetic crosses.

80. (D) Assertion (A) is false but Reason (R) is true.
The Law of Independent Assortment does not apply universally to all gene pairs because linked genes situated close together on the same chromosome tend to be inherited together during meiosis. Physical linkage prevents independent segregation, modifying standard Mendelian dihybrid ratios unless crossing over breaks parental allele associations.

81. (C) The XX-XY sex chromosome system
Sex determination in humans operates via the XX-XY sex chromosome system. Human females possess two identical X chromosomes (XX) and produce uniform eggs, whereas males carry one X and one Y chromosome (XY), generating two distinct types of sperm that determine the biological sex of offspring during fertilization.

82. (B) 22 pairs
Human somatic cells contain 23 pairs of chromosomes, totaling 46 individual chromosomes. Among these, 22 pairs are classified as autosomes, which regulate general somatic traits across sexes. The remaining single pair consists of sex chromosomes (XX or XY), which govern biological sex determination and sex-linked characteristics in humans.

83. (D) Inborn metabolic error
Alkaptonuria was identified by Archibald Garrod as an autosomal recessive disorder caused by a enzyme deficiency in homogentisic acid metabolism. Recognizing its Mendelian inheritance pattern, Garrod introduced the concept of inborn errors of metabolism, connecting inherited gene mutations directly to specific metabolic pathway disruptions in humans.

84. (A) Mother
A human male child inherits his single X chromosome exclusively from his mother, while receiving his Y chromosome from his father. Because paternal gametes contribute either an X or Y chromosome, male offspring always receive their paternal Y chromosome, ensuring maternal origin for their X-linked genetic traits.

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43. In standard genetics, how is a 'gene' best defined at the molecular level?
(A) A complex nuclear lipid molecule that directly regulates eukaryotic cell division.
(B) A DNA sequence coding for a functional product like a protein.
(C) The complete structural set of functional chromosomes within a diploid cell.
(D) A specialized nuclear protein architecture maintaining nuclear shape.

44. The specific physical location or position of a gene on a chromosome is called its:
(A) Allele
(B) Locus
(C) Centromere
(D) Chiasma

45. Consider the following steps and molecules involved in the Central Dogma of molecular biology:
1. Translation
2. Protein
3. DNA
4. mRNA
5. Transcription

Which of the following represents the correct sequential order?
(A) 3, 5, 4, 1, 2
(B) 3, 1, 4, 5, 2
(C) 5, 3, 1, 4, 2
(D) 4, 5, 3, 1, 2

46. DNA replication is described as 'semi-conservative'. What does this mean?
(A) One resulting daughter double helix is completely new, while the other remains entirely parental.
(B) The newly synthesized DNA molecule is randomly assembled from dispersed fragments of parent DNA.
(C) Each new DNA helix has one parental strand and one synthesized strand.
(D) Only a specific half of the entire organismal genome undergoes replication in a given cycle.

47. Which enzyme is primarily responsible for adding new free nucleotides to the growing DNA chain during replication?
(A) DNA Helicase
(B) DNA Ligase
(C) RNA Primase
(D) DNA Polymerase

48. During DNA replication, in which direction does the DNA polymerase continuously synthesize the new leading strand?
(A) 3' to 5' direction
(B) From the centromere to the telomere
(C) 5' to 3' direction
(D) From the telomere to the centromere

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49. What is the name given to the short segments of newly synthesized DNA on the lagging strand during replication?
(A) Watson fragments
(B) Okazaki fragments
(C) Satellite DNA
(D) Primer segments

50. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): DNA replication is continuous on the leading strand but discontinuous on the lagging strand.
Reason (R): DNA polymerase can only add nucleotides in the 5' to 3' direction.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

51. Which British geneticist is widely regarded as the 'Father of DNA fingerprinting' for his pioneering work in 1984?
(A) Alec Jeffreys
(B) James Watson
(C) Kary Mullis
(D) Frederick Sanger

52. The technique of DNA fingerprinting primarily relies on identifying differences in which specific regions of the human genome?
(A) Coding exon sequences that specify functional metabolic proteins
(B) Non-coding transfer RNA genes present on cellular chromosomes
(C) Variable Number of Tandem Repeats (VNTRs)
(D) Highly conserved histone protein genes in the eukaryotic genome

53. Which technique is commonly used in forensic science to amplify a small trace sample of DNA

the second filial (F_2) generation, establishing the sequential framework of classical inheritance crosses.

96. (D) Autosomal recessive
Phenylketonuria is an autosomal recessive metabolic disorder caused by mutations in the phenylalanine hydroxylase gene located on an autosome. Individuals with two defective alleles cannot convert phenylalanine to tyrosine, causing toxic phenylalanine accumulation that leads to severe intellectual disability and neurological impairment if untreated early.

97. (C) 45, X_0
Turner syndrome is a sex chromosome abnormality caused by non-disjunction, resulting in monosomy X. Affected females possess 45 total chromosomes instead of 46, designated as 45, X_0. Clinical features include underdeveloped ovaries, short stature, webbed neck, and sterility due to missing sex chromosome material in cells.

98. (B) Klinefelter syndrome
Klinefelter syndrome affects males possessing an extra X chromosome, resulting in a 47, XXY karyotype. This chromosomal trisomy causes testicular dysgenesis, reduced testosterone synthesis, infertility, gynecomastia, and tall stature with feminine physical features due to altered sex chromosome balance during early human development.

99. (D) Autosomal recessive trait
Cystic fibrosis is an autosomal recessive disease caused by mutations in the CFTR gene located on human chromosome 7. Inheriting two mutant copies disrupts transmembrane chloride transport, producing abnormally thick mucus that obstructs respiratory pathways and pancreatic ducts, impairing digestive and pulmonary functions severely over time.

100. (A) P-2, Q-1, R-4, S-3
Down syndrome results from trisomy 21, and haemophilia is an X-linked recessive disorder. Sickle cell anemia is caused by an autosomal recessive gene mutation, while Turner syndrome stems from X-chromosome monosomy (45, X_0), matching each genetic disorder with its underlying chromosomal or genetic etiology correctly.

101. (C) Epistasis
Epistasis is a non-allelic gene interaction where one gene masks or modifies the phenotypic expression of another gene at a distinct locus. The gene suppressing the phenotype is termed epistatic, whereas the suppressed gene is hypostatic, resulting in altered Mendelian dihybrid phenotypic ratios in offspring populations.

102. (A) Lethal genes
Lethal genes cause mortality in organisms carrying them, usually when expressed in a homozygous state. These mutations disrupt critical developmental or metabolic pathways, causing pre-natal embryonic death or early post-natal lethality, which alters expected Mendelian phenotypic ratios among surviving offspring in breeding crosses dramatically.

103. (D) 9:7
Complementary gene interaction occurs when two non-allelic dominant genes must both be present for a specific phenotype to manifest. If either gene is homozygous recessive, the dominant phenotype fails to develop, modifying the standard 9:3:3:1 dihybrid F_2 ratio into a characteristic 9:7 phenotypic distribution pattern.

104. (B) Polygenic inheritance
Quantitative inheritance, also known as polygenic inheritance, refers to traits controlled by multiple additive genes. Because individual gene effects are cumulative, offspring exhibit continuous quantitative variation across a spectrum, as seen in kernel colour in wheat, human height, and animal birth weights in populations.

105. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
A test cross accurately determines whether an individual showing a dominant phenotype is homozygous dominant or heterozygous. Crossing the dominant organism with a homozygous recessive partner exposes hidden recessive alleles, because recessive offspring will only appear if the dominant parent contributes a recessive allele to them.

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106. (D) Genetically Modified Organism
GMO stands for Genetically Modified Organism. It refers to any biological organism whose genetic material has been altered using modern

(B) Nucleoside
(C) Amino acid
(D) Monosaccharide

22. In the DNA double helix model, the structural backbone of the strands is composed of which two components?
(A) Nitrogenous bases and sugar
(B) Nitrogenous bases and phosphate groups
(C) Histone proteins and sugar
(D) Sugar and phosphate groups

23. The two strands of a DNA double helix are described as 'antiparallel'. What does this mean?
(A) Both strands run in the 5' to 3' direction.
(B) One strand runs 5' to 3' and the other runs 3' to 5'.
(C) The strands are perfectly parallel but do not interact.
(D) The strands cross each other at regular intervals forming right angles.

24. In which year did James Watson and Francis Crick propose the famous double helix model of DNA?
(A) 1928
(B) 1944
(C) 1953
(D) 1962

25. Match the scientists in List I with their major contribution to the study of genetic material in List II:
List I: (Scientist)
P. Friedrich Miescher
Q. Frederick Griffith
R. Avery, MacLeod, McCarty
S. Hershey and Chase
List II: (Contribution)
1. Discovered the transformation principle in bacteria
2. Discovered 'Nuclein' in pus cells
3. Proved that DNA is the transforming chemical principle
4. Unequivocally proved DNA is the genetic material using bacteriophages
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-1, S-4

26. Which specific pentose sugar is found in the nucleotides of a DNA molecule?
(A) Deoxyribose
(B) Ribose
(C) Glucose
(D) Fructose

27. Which functional group imparts an acidic nature and a net negative charge to the DNA molecule?
(A) Hydroxyl group
(B) Phosphate group
(C) Methyl group
(D) Amino group

28. Nitrogenous bases in nucleic acids are classified as purines and pyrimidines. Which of the following are purines?
(A) Cytosine and Thymine
(B) Adenine and Guanine
(C) Adenine and Thymine
(D) Cytosine and Uracil

29. Which of the following pyrimidine bases is found only in RNA and is absent in standard DNA?
(A) Uracil
(B) Thymine
(C) Cytosine
(D) Guanine

30. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): DNA is typically double-stranded while RNA is typically single-stranded.
Reason (R): RNA molecules contain the sugar ribose instead of deoxyribose.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

31. According to Chargaff's rules for a double-stranded DNA molecule, which of the following mathematical relationships is always true?
(A) $A + T = G + C$
(B) $A = G$ and $T = C$
(C) $A + U = G + C$
(D) $A = T$ and $G = C$

32. In the Watson and Crick model of DNA, how many hydrogen bonds pair Guanine (G) with Cytosine (C)?
(A) One
(B) Two
(C) Three
(D) Four

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118. (A) P-3, Q-4, R-1, S-2
A 3:1 ratio represents the monohybrid F_2 phenotypic ratio, while 1:2:1 corresponds to the monohybrid F_2 genotypic ratio. The 9:3:3:1 ratio reflects dihybrid F_2 phenotypes, and a 1:1 ratio characterizes a monohybrid test cross, accurately pairing each Mendelian ratio with its corresponding cross type in classical genetics.

119. (A) I and II only
Co-dominance involves full simultaneous expression of both alleles, whereas incomplete dominance displays an intermediate blended phenotype. Human blood group AB exhibits co-dominance because both IA and IB antigens are expressed on red blood cells, making statement three incorrect and statements one and two correct in non-Mendelian inheritance.

120. (B) Genetics
The comprehensive investigation of Mendelian principles, Punnett square modeling, heredity mechanisms, gene structure, and patterns of variation falls under the biological discipline of genetics. Genetics provides the unifying scientific framework that explains how biological traits are encoded, expressed, and transmitted across generations of living organisms worldwide.

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genetic engineering techniques, incorporating recombinant DNA technology to introduce desirable traits such as pest resistance, enhanced nutritional value, or improved tolerance to environmental stress conditions.

107. (A) Resistant to bollworm insect pests
Bt Cotton is a genetically modified crop engineered by inserting the Cry gene from the soil bacterium Bacillus thuringiensis. This transgene enables the plant to produce endotoxin proteins that specifically target and destroy destructive bollworm insect pests, protecting crop yields and reducing chemical pesticide usage significantly.

108. (B) Vitamin A
Golden Rice is a genetically engineered rice crop developed to synthesize beta-carotene, a precursor of Vitamin A, in its edible endosperm. It was developed to combat Vitamin A deficiency, which causes blindness and impaired immune function among populations reliant on traditional rice diets in developing nations worldwide.

109. (B) Pharmacogenomics
Pharmacogenomics combines pharmacology and genomics to analyze how an individual's genetic profile influences their response to therapeutic drugs. By correlating gene variations with drug metabolism and efficacy, pharmacogenomics enables personalized medicine, optimizing therapeutic dosages while minimizing adverse drug reactions in medical patients globally.

110. (A) P-2, Q-4, R-1, S-3
Bt Cotton provides insect resistance against bollworms, whereas Golden Rice is enriched with Vitamin A. Gene therapy focuses on replacing or correcting defective human genes, and genetic counseling assesses inheritance risks for families, matching each modern genetic application directly to its corresponding biological description accurately.

111. (B) 25%
Self-pollination of a heterozygous tall pea plant (Tt × Tt) yields a 1:2:1 genotypic ratio: 25% TT, 50% Tt, and 25% tt. Because dwarfness is a recessive trait requiring the tt genotype, exactly 25 percent of the resulting offspring will express the dwarf phenotype in the F_2 generation.

112. (D) 1/16
In a Mendelian dihybrid cross between double heterozygotes (AaBb × AaBb), sixteen genotype combinations are formed in the Punnett square. Because inheriting double recessive alleles requires receiving recessive gametes (ab) from both parents, exactly 1/16 of the progeny will be completely homozygous recessive (aabb) in total.

113. (C) Chromosomal DNA molecule
Deoxyribonucleic acid (DNA) contained within chromosomes forms the structural and chemical foundation of heredity. DNA molecules store biological information in their nucleotide base sequences, enabling stable replication, precise transmission during reproduction, and regulated expression of genetic traits across successive generations of living organisms globally.

114. (B) Evolution
Genetic variation provides essential raw material for evolutionary processes. Without genetic differences among individuals in a population, natural selection could not act to alter allele frequencies over time, limiting a species' capacity to adapt to environmental changes and evolve across successive generations in nature.

115. (A) I and II only
Mendel succeeded because he simplified experiments by focusing on one or two contrasting traits at a time, applying quantitative statistical analysis to large sample sizes. He chose independently assorting traits located on different chromosomes, ensuring statements one and two accurately reflect his key experimental strategies in genetics.

116. (B) 1, 2, 3, 4
Arranging genetic structures by physical complexity begins with single nucleotide monomers, which polymerize to form functional genes. Linear DNA containing genes packages into compact chromosomes, and these chromosomes reside inside the eukaryotic nucleus, establishing the precise hierarchical sequence: 1, 2, 3, 4 overall.

117. (C) Linked genes
Genes situated near each other on the same chromosome are called linked genes. Because physical proximity inhibits independent assortment during meiosis, these genes tend to be inherited together as a unit, producing higher frequencies of parental phenotypes and deviating from standard Mendelian dihybrid ratios in genetic crosses.

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(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

11. Which term describes one of the two identical halves of a replicated chromosome that are joined together at the centromere?
(A) Centrosome
(B) Chromatid
(C) Chromatin
(D) Telomere

12. The structural ends of a linear chromosome are known as telomeres. What is their primary role?
(A) They initiate bidirectional DNA replication at origin sites.
(B) They protect linear chromosome ends from enzymatic degradation.
(C) They serve as specialized attachment sites for spindle fibers.
(D) They contain transcriptionally active genes for ribosomal RNA.

13. During the anaphase of cell division, a metacentric chromosome assumes which of the following shapes as it moves towards the pole?
(A) V-shape
(B) I-shape
(C) J-shape
(D) L-shape

14. Some chromosomes have non-staining secondary constrictions at a constant location. This gives the appearance of a small fragment called a:
(A) Kinetochore
(B) Centrosome
(C) Satellite
(D) Nucleosome

15. Consider the following statements regarding human chromosomes:
I. Somatic cells contain a diploid number of chromosomes.
II. Autosomes directly determine the sex of an individual.
III. The Y chromosome is significantly smaller than the X chromosome.
IV. Human gametes contain 23 pairs of chromosomes.
Which combination of statements is correct?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

16. What defines a pair of homologous chromosomes?
(A) Two non-homologous chromosomes that determine the sexual phenotype of an organism.
(B) Two identical sister chromatids physically joined together at a shared centromere.
(C) A maternal and paternal pair with matching size, structure, and gene loci.
(D) Any two arbitrary chromosomes co-existing within a single somatic cell nucleus.

17. At which stage of cell division are chromosomes most condensed and easiest to study under a microscope?
(A) Prophase
(B) Metaphase
(C) Anaphase
(D) Telophase

18. During which phase of cell division do sister chromatids separate and move towards opposite poles?
(A) Prophase
(B) Metaphase
(C) Anaphase
(D) Interphase

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19. Nucleic acids are long chain polymers found in all living cells. What are the two primary types of nucleic acids?
(A) DNA and RNA
(B) Amino acids and Fatty acids
(C) Glucose and Glycogen
(D) Histones and Non-histones

20. Which of the following represents the correct hierarchical sequence of DNA packaging in a eukaryotic cell, from the simplest to the most complex structure?
(A) DNA double helix → Chromatin → Nucleosome → Chromosome
(B) DNA double helix → Nucleosome → Chromatin → Chromosome
(C) Nucleosome → DNA double helix → Chromatin → Chromosome
(D) Chromatin → DNA double helix → Nucleosome → Chromosome

21. What is the basic monomeric unit (building block) that links together to form a nucleic acid?
(A) Nucleotide

CHAPTER 11
Chromosomes and Nucleic Acids

1. The term 'chromosome' was first coined by which of the following scientists to describe the thread-like structures in the nucleus?
(A) Wilhelm Roux
(B) Heinrich Wilhelm Waldeyer
(C) Thomas Hunt Morgan
(D) Gregor Mendel

2. In a typical eukaryotic cell, where are the chromosomes primarily located?
(A) Cytoplasm
(B) Mitochondria
(C) Endoplasmic reticulum
(D) Nucleus

3. Chromatin is composed of DNA and basic proteins. Which specific basic proteins are responsible for packaging DNA in eukaryotes?
(A) Histones
(B) Albumins
(C) Globulins
(D) Keratins

4. In the structure of a nucleosome, the DNA double helix is wrapped around a core containing how many histone protein molecules?
(A) Four (Tetramer)
(B) Six (Hexamer)
(C) Eight (Octamer)
(D) Ten (Decamer)

5. Match the type of chromosome in List I with its description based on centromere position in List II:
List I: (Chromosome Type)
P. Metacentric
Q. Sub-metacentric
R. Acrocentric
S. Telocentric
List II: (Description)
1. Centromere situated strictly at the terminal end
2. Centromere situated in the exact middle
3. Centromere situated slightly away from the middle
4. Centromere situated very close to one end

(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-3, S-1

6. What is the standard diploid number of chromosomes in a normal human somatic cell?
(A) 23
(B) 44
(C) 46
(D) 48

7. Out of the 23 pairs of chromosomes in a human cell, how many pairs are considered autosomes?
(A) 1 pair
(B) 21 pairs
(C) 22 pairs
(D) 23 pairs

8. Which of the following combinations correctly represents the sex chromosomes of a normal human male?
(A) XX
(B) YY
(C) XY
(D) XO

9. What is the primary function of the centromere in a chromosome?
(A) To synthesize ribosomal RNA within specialized nucleolar regions
(B) To protect the ends of linear chromosomes from degradation
(C) To mediate genetic crossing over between chromatids during meiosis
(D) To hold sister chromatids together and attach spindle fibers

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): DNA is tightly packaged into nucleosomes within the nucleus of a eukaryotic cell.
Reason (R): The negatively charged DNA binds strongly to the positively charged histone octamer.

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33. In the DNA double helix, Adenine (A) always pairs with Thymine (T) via how many hydrogen bonds?
(A) One
(B) Two
(C) Three
(D) Four

34. Which of the following is the most abundant type of RNA present in a typical cellular environment?
(A) Messenger RNA (mRNA)
(B) Transfer RNA (tRNA)
(C) Small nuclear RNA (snRNA)
(D) Ribosomal RNA (rRNA)

35. Consider the following statements about the types of RNA:
I. mRNA carries the genetic code from DNA to the ribosomes.
II. tRNA acts as an adapter molecule to bring amino acids to the ribosome.
III. rRNA is primarily responsible for storing genetic information long-term.
IV. RNA molecules are typically less stable and mutate faster than DNA.
Which combination of statements is correct?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

36. What is the primary role of messenger RNA (mRNA) in a cell?
(A) It forms the main structural and catalytic component of active cellular ribosomes.
(B) It carries specific amino acids to ribosomes during peptide chain assembly.
(C) It carries genetic instructions from nuclear DNA to guide protein synthesis.
(D) It regulates the unzipping and enzymatic unwinding of parental DNA strands.

37. Which type of RNA is commonly depicted as having a 'clover-leaf' structure in its two-dimensional representation?
(A) tRNA
(B) mRNA
(C) rRNA
(D) hnRNA

38. Chemically, how does the pentose sugar in RNA differ from the pentose sugar in DNA?
(A) RNA sugar has an extra methyl group at the 3' position.
(B) RNA sugar lacks a hydroxyl (-OH) group at the 3' position.
(C) RNA sugar is a six-carbon hexose, while DNA sugar is a five-carbon pentose.
(D) RNA sugar has a hydroxyl (-OH) group at the 2' position, which DNA lacks.

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39. Why is DNA considered a better molecule for long-term storage of genetic information compared to RNA?
(A) DNA is chemically highly reactive due to its prominent free 2'-OH group.
(B) DNA is structurally more stable and less prone to degradation.
(C) RNA contains uracil paired with thymine which causes rapid breakdown.
(D) RNA molecules are invariably rigid double-stranded helical complexes.

40. Match the types of RNA in List I with their primary functions in List II:
List I: (Type of RNA)
P. mRNA
Q. tRNA
R. rRNA
S. snRNA
List II: (Primary Function)
1. Reads the genetic code and brings the correct amino acid
2. Combines with proteins to form the site of translation
3. Contains the codons transcribed from DNA
4. Involved in splicing and processing of pre-mRNA in eukaryotes
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-4, S-3

41. A nucleoside differs from a nucleotide because it lacks which of the following components?
(A) A nitrogenous base
(B) A pentose sugar
(C) A hydroxyl group
(D) A phosphate group

42. Successive nucleotides in a single strand of a nucleic acid are linked together by which type of chemical bond?
(A) Phosphodiester bond
(B) Peptide bond
(C) Glycosidic bond
(D) Hydrogen bond

85. (A) I and II only
The IA allele produces surface antigen A on red blood cells, while the i allele produces no antigen. IA and IB display co-dominance rather than incomplete dominance, as both alleles express their respective antigens fully in AB blood types without blending or partial masking, confirming statement three is incorrect.

86. (A) Mating or marriage
In standard pedigree diagrams, a horizontal line drawn directly between a male symbol (square) and a female symbol (circle) represents a mating or marriage relationship. This line connects parents, with downward vertical lines branching off to display the offspring produced from that marital union across generations.

87. (D) Consanguineous mating between closely related individuals
A double horizontal line connecting a male and female symbol in a human pedigree chart specifically signifies consanguineous mating, which is a union between closely related individuals sharing common ancestors. Tracking consanguinity helps geneticists evaluate increased risks of autosomal recessive genetic disorders appearing in offspring within families.

88. (B) A female
Pedigree analysis employs consistent geometric shapes to represent biological individuals within multi-generational family trees. In standard pedigree notation, a circle designates a female individual, whereas a square denotes a male individual, providing a standardized visual layout for evaluating inheritance patterns across generations in human genetics.

89. (C) Sex unspecified
In standard human pedigree charts, a diamond symbol represents an individual whose biological sex is unspecified or unknown. Geneticists utilize diamond shapes during pedigree construction when documenting recorded family historical data where gender information is either unavailable, irrelevant, or intentionally omitted for privacy considerations in studies.

90. (D) P-3, Q-1, R-4, S-2
In standard pedigree notation, a square symbolizes a male, a circle represents a female, and a diamond indicates unspecified sex. Fully shaded symbols denote individuals affected by the genetic condition being traced, establishing uniform graphical representations for analyzing inheritance patterns across family lines in human pedigree charts.

91. (A) Mutation
A mutation is defined as a sudden, stable, and heritable change in the nucleotide sequence of an organism's genome. Mutations introduce novel genetic variations into populations by altering gene structures or chromosomal arrangements, serving as the ultimate source of all evolutionary changes over generations within living organisms.

92. (B) Crossing over (Recombination)
Crossing over, or genetic recombination, occurs during prophase I of meiosis when non-sister chromatids of homologous chromosomes exchange genetic material. This physical swapping reshuffles maternal and paternal alleles, producing novel recombinant chromatids that increase genetic diversity among resulting haploid gametes during sexual reproduction cycles.

93. (B) Genetic recombination and independent assortment
Continuous variations in natural populations involve gradual phenotypic gradients controlled by polygenic inheritance and environmental influences. These variations are primarily driven by independent assortment and genetic recombination during meiotic division, which continuously recombine existing alleles into novel combinations without relying on sudden structural chromosomal mutations occurring.

94. (A) Genotype
Monozygotic, or identical, twins originate from a single fertilized egg that splits into two embryos during early cleavage. Consequently, monozygotic twins share an identical genetic constitution and identical genotype, although post-natal environmental influences and epigenetic modifications can introduce minor physical variations later in life between them.

95. (B) P generation → Gametes → F_1 generation → F_2 generation
A standard Mendelian experiment begins with true-breeding parent (P) plants. Gametes produced by these parents unite to form the first filial (F_1) generation. Self-pollination of F_1 individuals generates gametes that fuse to yield

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into a sufficiently large quantity for fingerprinting analysis?
(A) Polymerase Chain Reaction (PCR)
(B) Southern Blotting hybridization analysis
(C) Agarose Gel Electrophoresis separation
(D) High-resolution X-ray Crystallography

54. Which term describes the complete set of genetic instructions, including all the genes and non-coding sequences, present in a single haploid set of chromosomes of an organism?
(A) Proteome
(B) Karyotype
(C) Transcriptome
(D) Genome

55. Match the enzymes involved in DNA replication in List I with their primary functions in List II:
List I: (Enzyme)
P. Helicase
Q. DNA Ligase
R. DNA Polymerase
S. Primase
List II: (Function)
1. Synthesizes a short RNA primer to initiate replication
2. Unwinds the DNA double helix
3. Joins the gaps between Okazaki fragments
4. Adds deoxyribonucleotides to the growing DNA chain
(A) P-2, Q-3, R-4, S-1
(B) P-1, Q-4, R-3, S-2
(C) P-2, Q-4, R-3, S-1
(D) P-3, Q-2, R-1, S-4

56. The human genome sequenced during the Human Genome Project refers to the genetic material of a single haploid set. How many chromosomes make up this haploid human genome?
(A) 22
(B) 23
(C) 44
(D) 46

57. The Human Genome Project (HGP) was a massive international scientific research project. In which year was it officially launched?
(A) 1980
(B) 1990
(C) 2000
(D) 2003

58. According to the findings of the Human Genome Project, the human genome is composed of approximately how many base pairs?
(A) 3 million
(B) 30 million
(C) 3 billion
(D) 30 billion

59. What was one of the primary and most significant goals of the Human Genome Project?
(A) To successfully clone a complete human being in laboratory conditions.
(B) To sequence all chemical base pairs in human DNA.
(C) To completely cure all known inherited genetic diseases instantly.
(D) To synthesize a functional artificial chromosome entirely from scratch.

60. Consider the following statements regarding the findings of the Human Genome Project:
I. Less than 2% of the human genome codes for proteins.
II. Chromosome 1 has the most genes of all human chromosomes.
III. Repeated sequences make up very small portion of the human genome.
IV. Almost 99.9% of the nucleotide bases are exactly the same in all people.
Which combination of statements is correct?
(A) I, II, and III
(B) I, II, and IV
(C) II, III, and IV
(D) I, III, and IV

61. A type of chromosomal aberration where a segment of a chromosome is lost, resulting in the loss of genetic material, is known as:
(A) Deletion
(B) Duplication
(C) Inversion
(D) Translocation

62. When a segment of one chromosome breaks off and becomes attached to a different, non-homologous chromosome, the aberration is termed:
(A) Inversion
(B) Deletion
(C) Translocation
(D) Polyploidy

63. The condition in which an organism gains or loses one or a few chromosomes, deviating from

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the exact multiple of the haploid set (e.g., 2_{n+1} or 2_{n-1}), is called:
(A) Euploidy
(B) Polyploidy
(C) Monoploidy
(D) Aneuploidy

64. Down syndrome is a well-known genetic disorder. What is the underlying chromosomal abnormality that causes it?
(A) Trisomy of chromosome 18
(B) Monosomy of the X chromosome
(C) Trisomy of chromosome 21
(D) An extra Y chromosome

65. Turner syndrome is a chromosomal disorder found in females. Which of the following karyotypes represents Turner syndrome?
(A) 47, XXY
(B) 45, XO
(C) 47, XXX
(D) 46, XX

66. A male individual presenting with overall masculine development, gynaecomastia (breast development), and sterility most likely has which chromosomal disorder?
(A) Down syndrome
(B) Turner syndrome
(C) Patau syndrome
(D) Klinefelter syndrome

67. Which of the following physical characteristics is a hallmark symptom typically associated with a child having Down syndrome?
(A) A broad flat face with a characteristic palmar crease
(B) Abnormally tall stature with long limbs
(C) Complete lack of skin pigmentation
(D) Webbed neck and lack of secondary sexual characteristics

68. Friedrich Miescher (1869) isolated an acidic substance from the nuclei of white blood cells. What did he originally name this substance, which we now know as DNA?
(A) Chromatin
(B) Gene
(C) Nuclein
(D) Histone

69. In 1928, Frederick Griffith conducted an experiment demonstrating the 'Transforming Principle'. Which microorganism did he use for this experiment?
(A) Streptococcus pneumoniae
(B) Escherichia coli
(C) Drosophila melanogaster
(D) Neurospora crassa

70. Match the chromosomal disorders in List I with their corresponding chromosomal anomaly in List II:
List I: (Chromosomal Disorder)
P. Down syndrome
Q. Klinefelter syndrome
R. Turner syndrome
S. Patau syndrome
List II: (Chromosomal Anomaly)
1. 47, XXY
2. Trisomy 13
3. Trisomy 21
4. 45, XO
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-1, S-2

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71. Alfred Hershey and Martha Chase used radioactive isotopes to prove DNA is the genetic material. Which two isotopes did they use to distinguish DNA from protein?
(A) Carbon-14 and Nitrogen-15
(B) Phosphorus-32 and Sulfur-35
(C) Oxygen-18 and Hydrogen-3
(D) Iodine-131 and Iron-59

72. Who biochemically characterized Griffith's transforming principle to prove that it was DNA, and not proteins or RNA, that caused transformation?
(A) Watson and Crick
(B) Sutton and Boveri
(C) Avery, MacLeod, and McCarty
(D) Jacob and Monod

73. Which of the following molecules primarily serves as the hereditary material in almost all living organisms, transmitting traits from parents to offspring?
(A) Protein
(B) Lipid
(C) Carbohydrate
(D) DNA

74. While DNA is the universal genetic material, some viruses (like Tobacco Mosaic Virus and HIV) rely on a different molecule for their genetic information. What is it?

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(A) RNA
(B) Plasmids
(C) Prions
(D) Viroids

75. Select the correct sequential order of the major steps involved in standard DNA fingerprinting:
(A) Isolation of DNA → Restriction Digestion → Gel Electrophoresis → Southern Blotting → Autoradiography
(B) Isolation of DNA → Southern Blotting → Gel Electrophoresis → Restriction Digestion → Autoradiography
(C) Autoradiography → Gel Electrophoresis → Restriction Digestion → Southern Blotting → Isolation of DNA
(D) Restriction Digestion → Isolation of DNA → Southern Blotting → Autoradiography → Gel Electrophoresis

76. The Chromosomal Theory of Inheritance, which unites Mendelian laws with chromosomal behavior during cell division, was independently proposed by:
(A) Charles Darwin and Alfred Wallace
(B) Walter Sutton and Theodor Boveri
(C) James Watson and Francis Crick
(D) Thomas Hunt Morgan and Hermann Muller

77. The physical separation of homologous chromosomes during meiosis accounts for which fundamental law of genetics proposed by Mendel?
(A) Law of Segregation
(B) Law of Dominance
(C) Law of Independent Assortment
(D) Law of Incomplete Dominance

78. Which of the following is a prominent application of DNA technology in modern agriculture, extensively cultivated in India?
(A) Production of recombinant human insulin
(B) Forensic crime scene investigation
(C) Cultivation of pest-resistant Bt Cotton
(D) Use of MRI scans for crop diseases

79. Recombinant DNA technology has revolutionized medicine. Which life-saving hormone was one of the first human proteins to be successfully produced in bacteria for diabetic patients?
(A) Glucagon
(B) Thyroxine
(C) Adrenaline
(D) Human Insulin

80. Consider the following practical applications of DNA technology:
I. DNA fingerprinting helps in resolving paternity disputes.
II. Gene therapy can theoretically replace defective genes to cure genetic disorders.
III. Recombinant DNA technology is used to create drought-resistant crops in arid regions like Rajasthan.
IV. Genetic modification is completely banned globally for food production.
Which combination of statements is correct?
(A) I, II, and III
(B) II, III, and IV
(C) I, III, and IV
(D) I, II, and IV

81. In genetics, a sudden, inheritable change in the DNA sequence of an organism is called a:
(A) Translation
(B) Mutation
(C) Transcription
(D) Recombination

82. Sickle cell anemia is a classic example of a genetic disorder caused by a change in a single nucleotide base pair. What type of mutation is this?
(A) Frameshift mutation
(B) Chromosomal deletion
(C) Polyploidy
(D) Point mutation

83. The insertion or deletion of one or two nucleotide bases in a DNA sequence generally causes the reading frame of the genetic code to shift. This is known as a:
(A) Frameshift mutation
(B) Silent mutation
(C) Point mutation
(D) Nonsense mutation

84. Mutagens are agents that induce mutations in DNA. Which of the following is an example of a physical mutagen?
(A) Concentrated nitrous acid solution
(B) Alkylating mustard gas chemical
(C) Ultraviolet (UV) radiation
(D) Intercalating ethidium bromide dye

85. Match the mutagenic agents in List I with their category in List II:
List I: (Mutagenic Agent)
P. X-Rays

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ANSWERS

1. (B) Heinrich Wilhelm Waldeyer
The German anatomist Heinrich Wilhelm Waldeyer coined the term chromosome in 1888 to describe the dark staining thread like cellular structures discovered inside the nucleus of eukaryotic cells. These structures represent condensed chromatin during nuclear division, carrying genetic information necessary for heredity and cellular regulation across successive generations of organisms.

2. (D) Nucleus
In typical eukaryotic cells, chromosomes are primarily located within the membrane bound nucleus. The nuclear envelope separates the genomic DNA from the surrounding cytoplasm, maintaining a controlled environment for transcription, replication, and genomic integrity. Nuclear chromatin condenses into distinct individual chromosomes during cell division to ensure accurate distribution of hereditary material.

3. (A) Histones
Histones are small basic proteins rich in positively charged amino acids such as lysine and arginine. They play a fundamental role in packaging eukaryotic nuclear DNA into repeating structural units called nucleosomes. By neutralizing the negative charge of the sugar phosphate backbone, histones facilitate dense compaction of genetic material within chromatin.

4. (C) Eight (Octamer)
The core particle of a nucleosome consists of an octamer composed of eight histone protein molecules, specifically two copies each of H_2A, H_2B, H_3, and H_4. Approximately 147 base pairs of double-stranded eukaryotic DNA wrap around this central protein core, achieving the initial level of chromosomal DNA condensation in eukaryotic cells.

5. (A) P-2, Q-3, R-4, S-1
Chromosomes are classified according to the relative position of the centromere along their length. A metacentric chromosome has its centromere in the middle, sub-metacentric slightly away from the center, acrocentric very close to one end creating unequal arms, and telocentric strictly at the terminal end of the overall chromosome structure.

6. (C) 46
Normal human somatic cells possess a diploid chromosome complement of 46 chromosomes, organized into 23 matching pairs. This full set comprises 22 pairs of autosomal chromosomes along with one pair of sex chromosomes. Maintaining this specific diploid number is crucial for normal cellular functioning, development, and genetic stability across cell divisions.

7. (C) 22 pairs
In human somatic cells, 22 of the 23 total chromosomal pairs are autosomes, which govern non-sex-linked traits and general physiological characteristics. These autosomes are numbered 1 through 22 based on size. The remaining single pair consists of sex chromosomes, which determine the biological sex and related phenotypic traits of an individual.

8. (C) XY
In humans, biological sex determination operates on an XX and XY chromosomal system. A normal human male possesses one X chromosome inherited from the mother and one Y chromosome inherited from the father, yielding an XY sex chromosome combination alongside 22 pairs of autosomes to complete the 46 total chromosomes.

9. (D) To hold sister chromatids together and attach spindle fibers
The centromere is a specialized primary constriction region on a chromosome that physically joins identical sister chromatids together following DNA replication. It serves as the assembly site for kinetochore protein complexes, which anchor spindle fibers during cell division to ensure equal alignment and separation of chromosomes into daughter cell nuclei.

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(C) Segregation
(D) Crossing over

96. If a researcher wants to study the exact morphology and number of chromosomes, which phase of the cell cycle is the best to observe?
(A) Interphase
(B) Prophase
(C) Metaphase
(D) Telophase

97. Which molecular substance acts as the primary instructional manual for synthesizing the proteins required by a living cell?
(A) Adenosine Triphosphate (ATP)
(B) Deoxyribonucleic Acid (DNA)
(C) Glycogen
(D) Cholesterol

98. According to the standard Watson and Crick B-DNA model, what is the distance (pitch) of one complete turn of the DNA helix?
(A) 0.34 nm
(B) 2.0 nm
(C) 3.4 nm
(D) 34 nm

99. The DNA double helix model was largely based on X-ray diffraction data produced by which researchers?
(A) Rosalind Franklin and Maurice Wilkins
(B) Erwin Chargaff and Linus Pauling
(C) Matthew Meselson and Franklin Stahl
(D) Colin MacLeod and Maclyn McCarty

100. Match the nucleic acid components in List I with their biochemical category in List II:
List I: (Nucleic Acid Component)
P. Adenine
Q. Cytosine
R. Deoxyribose
S. Phosphate
List II: (Biochemical Category)
1. Pyrimidine base
2. Purine base
3. Inorganic acid component
4. Pentose sugar
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-1, Q-3, R-4, S-2

101. During transcription, if a sequence on the DNA template strand is Adenine (A), which complementary base will be added to the newly forming RNA strand?
(A) Uracil (U)
(B) Thymine (T)
(C) Cytosine (C)
(D) Guanine (G)

102. Which of the following is a pyrimidine base found in both DNA and RNA?
(A) Adenine
(B) Guanine
(C) Thymine
(D) Cytosine

103. If a double-stranded DNA sample contains 20% Adenine, what will be the percentage of Guanine in the same sample according to Chargaff's rules?
(A) 20%
(B) 30%
(C) 40%
(D) 60%

104. Which cellular organelle, composed heavily of rRNA and proteins, serves as the actual site of translation (protein synthesis)?
(A) Lysosome
(B) Golgi apparatus
(C) Ribosome
(D) Smooth Endoplasmic Reticulum

105. Consider the following phases of a typical eukaryotic cell cycle:
1. S phase (Synthesis)
2. G1 phase (Gap 1)
3. M phase (Mitosis)
4. G2 phase (Gap 2)
Which of the following represents the correct chronological order starting from the post-mitotic resting phase?
(A) 1, 2, 4, 3
(B) 2, 1, 4, 3
(C) 2, 4, 1, 3
(D) 3, 2, 1, 4

106. In some cases, RNA molecules can act as biological catalysts just like protein enzymes. What are these catalytic RNA molecules called?
(A) Ribozymes
(B) Ligases
(C) Polymerases
(D) Transcriptases

107. Which specific nucleotide is widely known as the primary 'energy currency' of the cell?

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Q. Nitrous acid
R. UV rays
S. Acridine dye

List II: (Category)

1. Chemical mutagen (deaminating agent)
2. Chemical mutagen (intercalating agent)
3. Physical mutagen (ionizing radiation)
4. Physical mutagen (non-ionizing radiation)

(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-3, Q-2, R-4, S-1

86. In modern genetic research, the revolutionary CRISPR-Cas9 system is widely used for what specific purpose?
(A) Rapidly amplifying specific target DNA sequences for PCR analysis.
(B) High-throughput sequencing of entire genomic sequences rapidly.
(C) Separating non-digested DNA fragments based on molecular size.
(D) Precise gene editing and targeted DNA modification.

87. The basic concept of gene therapy involves:
(A) Administering synthetic mutagenic chemicals to alter healthy target genes.
(B) Delivering functional genes into cells to compensate for defective ones.
(C) Applying non-invasive physical therapy to restore defective muscle genetics.
(D) Selectively breeding organisms over generations with desirable phenotypic traits.

88. In a non-dividing nucleus, the DNA-protein complex appears as an entangled mass of thread-like structures called:
(A) Spindle fibers
(B) Nucleoli
(C) Chromatin
(D) Centrioles

89. Histone proteins possess a net positive charge due to the abundance of which two basic amino acids?
(A) Serine and Threonine
(B) Glutamic acid and Aspartic acid
(C) Valine and Leucine
(D) Lysine and Arginine

90. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): During the packaging of DNA, the DNA molecule wraps tightly around the histone octamer to form a nucleosome.
Reason (R): DNA carries a negative charge due to its phosphate groups, while histone proteins carry a positive charge.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

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91. A normal human sperm cell carries a haploid set of chromosomes. How many autosomes are present in a single human sperm?
(A) 22
(B) 23
(C) 44
(D) 46

92. In humans, the biological sex of a child is primarily determined by:
(A) The sex chromosome contributed by the ovum (egg).
(B) The sex chromosome contributed by the sperm.
(C) The nutritional status of the mother during pregnancy.
(D) The environmental temperature during fertilization.

93. What is the name of the specialized disc-shaped protein structures present on the sides of the centromere to which spindle fibers attach during cell division?
(A) Kinetochores
(B) Chiasmata
(C) Telomeres
(D) Nucleosomes

94. A chromosome with a centromere located slightly away from the middle, resulting in one shorter arm and one longer arm, is termed:
(A) Metacentric
(B) Acrocentric
(C) Sub-metacentric
(D) Telocentric

95. The exchange of genetic material between non-sister chromatids of homologous chromosomes during meiosis is called:
(A) Synapsis
(B) Disjunction

(A) Heat-killed S strain
(B) Heat-killed R strain
(C) Live bacteriophages
(D) Human white blood cells

118. In regions like Rajasthan, agricultural scientists use modern DNA technology to improve the genetic traits of crops suited for arid climates. The introduction of a foreign gene to create drought resistance makes the crop:
(A) A naturally occurring homologous crop variety.
(B) An artificially cloned cellular crop lineage.
(C) A chemically induced mutagenic crop variant.
(D) A transgenic or GM crop.

119. Colchicine is a chemical derived from a plant that is widely used in agricultural genetics. What specific effect does it have on dividing cells?
(A) It directly breaks phosphodiester bonds in the DNA double helix.
(B) It inhibits spindle formation, inducing polyploidy.
(C) It causes single nucleotide pair point mutations in nuclear genes.
(D) It rapidly degrades structural ribosomal RNA within nucleoli.

120. Which modern application of genomic research involves tailoring medical treatments and drug prescriptions specifically based on a patient's individual DNA profile?
(A) Cytogenetic chromosomal karyotyping analysis
(B) High-throughput Polymerase Chain Reaction
(C) Pharmacogenomics (Personalized medicine)
(D) Targeted oncological radiotherapy treatment

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(A) GTP
(B) ATP
(C) UTP
(D) CTP

108. In eukaryotic genes, the coding sequences that actually express themselves in the mature RNA are called:
(A) Introns
(B) Exons
(C) Promoters
(D) Terminators

109. During DNA replication, as helicase unwinds the double helix, tension builds up ahead of the replication fork. Which enzyme relieves this tension by cutting and rejoining the DNA strands?
(A) Topoisomerase
(B) RNA Primase
(C) DNA Ligase
(D) Endonuclease

110. Consider the following statements regarding DNA replication:
I. It occurs during the S phase of the cell cycle.
II. DNA synthesis always proceeds in the 3' to 5' direction.
III. The leading strand requires only one RNA primer to begin.
IV. The lagging strand is synthesized as a continuous long chain.
Which combination identifies the correct statements?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

111. DNA fingerprinting is highly useful for identifying individuals in forensic cases. Between which of the following individuals would the DNA fingerprints be 100% identical?
(A) Dizygotic (fraternal) twins
(B) A father and his biological son
(C) Two siblings born a year apart
(D) Monozygotic (identical) twins

112. Apart from the nucleus, a small amount of circular, double-stranded DNA genome is also found in which of the following animal cell organelles?
(A) Lysosomes
(B) Golgi bodies
(C) Mitochondria
(D) Ribosomes

113. While the Human Genome Project focused on humans, sequences of non-human model organisms were also mapped. Which was the first free-living organism to have its entire genome sequenced?
(A) Drosophila melanogaster (Fruit fly)
(B) Haemophilus influenzae (Bacterium)
(C) Mus musculus (Mouse)
(D) Arabidopsis thaliana (Plant)

114. A chromosomal mutation where a segment of a chromosome breaks off, flips 180 degrees, and reattaches to the same chromosome is known as:
(A) Deletion
(B) Duplication
(C) Translocation
(D) Inversion

115. Match the biochemical bonds in List I with their location in nucleic acid structures in List II:
List I: (Biochemical Bond)
P. Phosphodiester bond
Q. Hydrogen bond
R. N-glycosidic bond
S. Peptide bond
List II: (Location/Description)
1. Links the nitrogenous base to the pentose sugar
2. Links complementary bases across the two DNA strands
3. Links successive nucleotides along a single strand
4. Links amino acids in the resulting protein, not found in DNA
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-3, R-1, S-4

116. An individual with a karyotype containing 47 chromosomes due to trisomy of the 13th chromosome suffers from which syndrome?
(A) Down syndrome
(B) Edwards syndrome
(C) Patau syndrome
(D) Turner syndrome

117. In Griffith's experiment, the non-virulent R strain of bacteria was transformed into the virulent S strain by taking up genetic material from:

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10. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
DNA packaging in eukaryotic nuclei relies on electrostatic attraction between macromolecules. Phosphate groups impart a strong negative charge to DNA strands, whereas basic histone proteins are rich in lysine and arginine residues, giving the histone octamer a strong positive charge. This charge difference enables DNA to wrap tightly around histones.

11. (B) Chromatid
A chromatid is one of two identical longitudinal halves of a duplicated chromosome produced during the synthesis phase of the cell cycle. Joined at a common centromere, sister chromatids contain identical copies of genetic material until they are pulled apart into separate daughter chromosomes during the anaphase stage of cell division.

12. (B) They protect linear chromosome ends from enzymatic degradation.
Telomeres are specialized nucleoprotein caps situated at the terminal ends of eukaryotic linear chromosomes. Composed of repetitive nucleotide sequences and associated protective protein complexes, telomeres prevent chromosomal ends from enzymatic degradation, preserve overall genomic stability, and prevent linear DNA ends from fusing inappropriately with other active chromosomes during cell interphase.

13. (A) V-shape
During anaphase, sister chromatids are pulled toward opposite spindle poles as kinetochore microtubules shorten. In a metacentric chromosome, where the centromere is positioned centrally, equal drag on both equal-length arms causes the chromosome to bend into a distinct V-shape with its centromere leading toward the pole and arms trailing behind.

14. (C) Satellite
Certain eukaryotic chromosomes feature non-staining secondary constrictions located at consistent positions along their arms. The small chromosomal segment situated distal to this secondary constriction is called a satellite. Chromosomes possessing this structure are known as SAT-chromosomes, and their secondary constrictions are frequently associated with nucleolar organizer regions involved in ribosome synthesis.

15. (B) I and III
Human somatic cells carry a diploid set of 46 chromosomes, whereas gametes are haploid containing 23 individual chromosomes rather than 23 pairs. Furthermore, the human Y chromosome is markedly smaller in size and contains far fewer genes than the X chromosome. Autosomes regulate general cellular functions, while sex chromosomes directly determine biological sex.

16. (C) A maternal and paternal pair with matching size, structure, and gene loci.
Homologous chromosomes form a matching pair of chromosomes within a diploid organism, where one chromosome is inherited from the maternal parent and the other from the paternal parent. They share identical physical dimensions, centromere positions, and gene loci in the exact same sequence, although the specific alleles at those loci may differ.

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17. (B) Metaphase
Metaphase is the stage of cell division when chromatin reaches its maximum level of condensation. The individual chromosomes align along the equatorial plane of the spindle apparatus, presenting clearly defined morphological features such as centromeres and chromatids. Consequently, metaphase provides the ideal window for counting, karyotyping, and detailed structural examination under microscopy.

18. (C) Anaphase
Anaphase is characterized by the sudden splitting of centromeres, allowing sister chromatids to separate from one another. Pulled by shortening kinetochore spindle fibers, these now independent daughter chromosomes migrate toward opposite poles of the dividing cell. This precise mechanism ensures that each resulting daughter nucleus receives an identical set of chromosomes.

19. (A) DNA and RNA
Nucleic acids are long chain polymeric biomolecules essential for all living organisms. The two fundamental classes of nucleic acids are deoxyribonucleic acid and ribonucleic acid. Deoxyribonucleic acid primarily acts as the permanent storage repository for genetic instructions, while ribonucleic acid participates directly in translating that genetic information into functional cellular proteins.

20. (B) DNA double helix → Nucleosome → Chromatin → Chromosome
Genomic packaging follows a strict hierarchy of increasing structural organization inside eukaryotic cells. The linear double-stranded DNA double helix wraps around histone cores to form nucleosomes. Repeating nucleosomes condense into a flexible chromatin fiber, which undergoes extensive looping and higher-order supercoiling during nuclear division to condense into highly compacted visible individual chromosomes.

21. (A) Nucleotide
Nucleic acids are biopolymers composed of repeating monomeric units termed nucleotides. Every individual nucleotide is constructed from three distinct chemical components: a nitrogenous base, a five-carbon pentose sugar, and a phosphate group. Nucleotides link together via covalent phosphodiester linkages to form continuous single strands of DNA or RNA within living systems.

22. (D) Sugar and phosphate groups
The outer structural framework of each DNA strand consists of an alternating sugar and phosphate backbone. Alternating deoxyribose sugar rings and phosphate groups are linked together by strong covalent phosphodiester bonds. Nitrogenous bases project inward from this sugar phosphate backbone toward the central axis to form hydrogen-bonded base pairs with the opposite strand.

23. (B) One strand runs 5' to 3' and the other runs 3' to 5'.
The two complementary strands of a DNA double helix possess opposite chemical polarities, making them antiparallel. One strand is oriented in the 5 prime to 3 prime direction, ending with a free phosphate group at the 5 prime position, while the partner strand runs parallel in the reverse 3 prime to 5 prime orientation.

24. (C) 1953
In 1953, American biologist James Watson and British physicist Francis Crick deduced the famous three-dimensional double-helical structure of DNA. Their historic groundbreaking model was formulated using X-ray diffraction images generated by Rosalind Franklin and Maurice Wilkins alongside Erwin Chargaff's base ratio data, transforming modern molecular biology and genetics research fundamentally.

25. (A) P-2, Q-1, R-3, S-4
Key historical scientific milestones firmly established DNA as genetic material. Friedrich Miescher discovered nuclein in 1869, Frederick Griffith demonstrated bacterial transformation in 1928, Avery, MacLeod, and McCarty purified DNA as the transforming chemical factor in 1944, and Hershey and Chase provided definitive confirmation using radiolabeled bacteriophage infection experiments in 1952.

26. (A) Deoxyribose
DNA nucleotides contain 2-deoxyribose, a five-carbon pentose sugar ring missing an oxygen atom at the 2 prime carbon position compared to ribose. This absence of a reactive hydroxyl group at the 2 prime site increases chemical stability, safeguarding genetic instructions stored within double-stranded DNA against enzymatic hydrolysis inside living cells.

27. (B) Phosphate group
Phosphate groups in DNA form phosphodiester bonds between neighboring pentose sugar molecules along the sugar-phosphate backbone. At physiological pH, each phosphate moiety retains ionized hydroxyl groups bearing negative charges. These negatively charged phosphate groups make DNA an acidic polyanion, which promotes strong ionic interactions with positively charged nuclear proteins like histones.

28. (B) Adenine and Guanine
Purines are heterocyclic nitrogenous bases characterized by a two-ring structure consisting of a pyrimidine ring fused to an imidazole ring. In cellular nucleic acids, adenine and guanine are the two naturally occurring purine bases. They pair selectively with single-ring pyrimidine bases across complementary strands of nucleic acids via hydrogen bonding.

29. (A) Uracil
Nitrogenous pyrimidine bases include cytosine, thymine, and uracil, each having a single heterocyclic ring. Uracil occurs exclusively in ribonucleic acid, where it replaces thymine to pair with adenine during transcription and translation. Standard deoxyribonucleic acid contains thymine instead of uracil, which directly contributes to higher chemical stability in double-stranded DNA.

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30. (B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
DNA exists as a double-stranded helix whereas RNA is typically single-stranded due to different structural and evolutionary roles. Although RNA sugar contains ribose with a 2 prime hydroxyl group, double-strand formation in DNA is primarily driven by antiparallel complementary base pairing and hydrophobic stacking interactions rather than pentose sugar composition alone.

31. (D) A = T and G = C
Chargaff's rules state that in any double-stranded DNA molecule, the total amount of adenine equals the amount of thymine, and the total amount of guanine equals the amount of cytosine. This quantitative equivalence arises from selective complementary base pairing across opposing antiparallel strands, where purines always bind with specific pyrimidines.

32. (C) Three
Guanine and cytosine pair with each other across opposing strands of a DNA double helix via three specific hydrogen bonds. Because guanine-cytosine pairs share three hydrogen bonds compared to the two hydrogen bonds formed between adenine and thymine, DNA regions rich in guanine and cytosine exhibit higher thermal stability and melting temperatures.

33. (B) Two
Adenine forms two complementary hydrogen bonds with thymine across the anti-parallel strands of a DNA double helix. This specific pairing geometry maintains a uniform purine-pyrimidine distance along the longitudinal axis of the helical molecule, preserving consistent spatial dimensions across all base pair steps within standard double-stranded cellular genomic DNA structures.

34. (D) Ribosomal RNA (rRNA)
Ribosomal RNA is the most abundant class of RNA in living cells, constituting roughly 80 percent of total cellular RNA. Ribosomal RNA molecules complex with structural proteins to form ribosomes, which serve as the actual molecular machinery responsible for polypeptide synthesis during protein translation in both prokaryotic and eukaryotic organisms.

35. (B) I, II, and IV
Messenger RNA carries transcribed genetic codes from DNA to ribosomes, transfer RNA serves as an adapter delivering specific amino acids, and single-stranded RNA molecules are generally chemically less stable than DNA, mutating at higher rates. DNA, rather than ribosomal RNA, functions as the primary long-term repository for storing cellular genetic information.

36. (C) It carries genetic instructions from nuclear DNA to guide protein synthesis.
Messenger RNA acts as the intermediate transcript between nuclear genomic DNA and cytoplasmic protein synthesis. During transcription, RNA polymerase synthesizes messenger RNA based on the sequence of a gene. The resulting transcript carries triplet codons from the nucleus to cytoplasm, specifying the exact linear sequence of amino acids during ribosome translation.

37. (A) tRNA
Transfer RNA exhibits a characteristic clover-leaf secondary structure formed by intramolecular base pairing. This two-dimensional folding yields key functional regions, including an acceptor arm that binds a specific amino acid at its 3 prime end and an anticodon loop containing three bases that base-pair with complementary nucleotide codons on mRNA molecules.

38. (D) RNA sugar has a hydroxyl (-OH) group at the 2' position, which DNA lacks.
Ribose, the pentose sugar found in RNA, possesses a reactive hydroxyl group attached to its 2 prime carbon atom. In contrast, deoxyribose in DNA lacks an oxygen atom at this same position, having a hydrogen atom instead. This structural difference makes RNA more chemically reactive and prone to alkaline hydrolysis compared to DNA.

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39. (B) DNA is structurally more stable and less prone to degradation.
DNA is structurally and chemically more stable than RNA, making it ideal for long-term genetic storage. The absence of a 2 prime hydroxyl group on deoxyribose reduces susceptibility to hydrolytic degradation. Additionally, the double-helical structure protects nitrogenous bases inside, while thymine provides superior repair fidelity over uracil against spontaneous oxidative damage.

delivering functional corrective human genes, and genetic modification develops stress-tolerant agricultural crops. Genetic modification is widely permitted for crop production under established scientific regulatory bio-safety frameworks globally.

81. (B) Mutation
A mutation is defined as a sudden, heritable modification in the nucleotide sequence of an organism's genomic DNA. Mutations can arise spontaneously during replication errors or be induced by environmental mutagens. By introducing novel sequence variations into a gene pool, mutations act as the primary evolutionary source of genetic diversity.

82. (D) Point mutation
Sickle cell anemia is caused by a point mutation in the beta-globin gene on chromosome 11. A single base substitution converts adenine to thymine in the sixth codon, replacing hydrophilic glutamic acid with hydrophobic valine in the polypeptide chain. This single amino acid alteration causes hemoglobin to polymerize, distorting red blood cells into sickle shapes.

83. (A) Frameshift mutation
A frameshift mutation occurs when nucleotide bases are inserted or deleted in quantities not divisible by three within a coding region. Because translation reads mRNA in non-overlapping triplet codons, adding or removing one or two bases alters the translational reading frame downstream, resulting in completely altered amino acid sequences or premature stop codons.

84. (C) Ultraviolet (UV) radiation
Mutagens are categorized as physical, chemical, or biological agents that induce genomic mutations. Ultraviolet radiation is a physical non-ionizing radiation mutagen. When absorbed by DNA strands, ultraviolet light induces covalent cross-linking between adjacent pyrimidine bases, generating pyrimidine dimers such as thymine dimers that distort the double helix and inhibit DNA replication.

85. (A) P-3, Q-1, R-4, S-2
Mutagens induce DNA sequence changes via distinct mechanisms. High-energy X-rays serve as physical ionizing radiation causing chromosomal breaks, nitrous acid acts as a chemical deaminating agent altering cytosine and adenine, ultraviolet rays act as non-ionizing physical mutagens forming thymine dimers, and acridine dyes function as chemical intercalating agents causing frameshift mutations.

86. (D) Precise gene editing and targeted DNA modification.
The CRISPR-Cas9 system is a revolutionary prokaryotic adaptive immune mechanism adapted for precise genome editing. Guided by a custom single-guide RNA, the Cas9 endonuclease targets specific genomic loci and creates double-stranded DNA cuts. This enables scientists to insert, modify, or disrupt specific genes with high precision across diverse living organisms.

87. (B) Delivering functional genes into cells to compensate for defective ones.
Gene therapy is an advanced medical strategy designed to treat or prevent genetic diseases at their source. It involves transferring functional wild-type human genes into target somatic cells, frequently utilizing viral vectors, to compensate for mutated, non-functional, or missing genes and restore normal cellular synthesis of essential functional human proteins.

88. (C) Chromatin
During the interphase stage of the cell cycle, eukaryotic nuclear DNA resides in a relaxed, uncoiled network termed chromatin. Chromatin consists of linear genomic DNA complexed with basic histone proteins and non-histone architectural proteins. This diffuse structural state permits active gene transcription, RNA processing, and DNA replication prior to nuclear division.

89. (D) Lysine and Arginine
Histone proteins carry a strong net positive charge at physiological pH owing to an abundance of basic amino acids, specifically lysine and arginine. The positively charged amino acid side chains form electrostatic ionic interactions with the negatively charged phosphate backbone of genomic DNA, enabling dense physical packaging of DNA into nucleosome cores.

90. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Nucleosome assembly relies directly on electrostatic attraction between oppositely charged cellular macromolecules. Genomic DNA carries a net negative charge due to ionized

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50. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
DNA polymerase operates strictly in a 5 prime to 3 prime direction. At a replication fork, the leading template strand is oriented 3 prime to 5 prime, allowing continuous forward synthesis. The lagging template runs 5 prime to 3 prime, forcing synthesis to occur discontinuously in short Okazaki segments moving away from the fork.

51. (A) Alec Jeffreys
Sir Alec Jeffreys, a British geneticist at the University of Leicester, developed the technique of DNA fingerprinting in 1984. He discovered that human genomes contain hypervariable tandemly repeated DNA sequences, enabling unique individual genetic identification. His historic pioneer discovery revolutionized forensic science, paternity testing, and conservation biology applications globally.

52. (C) Variable Number of Tandem Repeats (VNTRs)
DNA fingerprinting targets Variable Number of Tandem Repeats, which are non-coding satellite DNA regions featuring repetitive nucleotide motifs. The copy number of these repeating sequences varies substantially between individuals, creating unique restriction fragment length patterns. This high degree of genomic polymorphism allows precise genetic differentiation between unrelated human individuals across populations.

53. (A) Polymerase Chain Reaction (PCR)
Polymerase Chain Reaction is an enzymatic technique used to exponentially amplify specific target DNA sequences in vitro. When forensic evidence yields only minute trace samples of DNA, such as hair follicles or tiny blood drops, PCR synthesizes millions of copies, providing sufficient quantities of genetic material for successful DNA fingerprinting profiling.

54. (D) Genome
A genome represents the total set of genetic material contained within a single haploid set of chromosomes of an organism. It encompasses all protein-coding genes, non-coding functional sequences, and non-coding structural regions. The genome provides the complete set of biological instructions necessary to build, maintain, and operate that living organism.

55. (A) P-2, Q-3, R-4, S-1
DNA replication requires the coordinated actions of multiple specialized enzymes. Helicase unwinds double-stranded parental DNA, primase synthesizes short RNA primers to provide initiation sites, DNA polymerase synthesizes new strands by adding complementary deoxyribonucleotides, and DNA ligase seals single-strand nicks by joining Okazaki fragments on the discontinuous lagging strand.

56. (B) 23
The haploid human genome comprises 23 individual chromosomes, consisting of 22 autosomes and 1 sex chromosome. Gametes such as eggs and sperm contain this haploid set. When haploid gametes fuse during fertilization, they restore the diploid complement of 46 chromosomes in the resulting zygote, maintaining chromosomal constancy across human biological generations.

57. (B) 1990
The Human Genome Project was an international mega-research enterprise officially launched in October 1990. Co-coordinated by the United States Department of Energy and National Institutes of Health alongside international partners, the project aimed to map and sequence all nucleotide base pairs in human DNA, reaching full successful completion in 2003.

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58. (C) 3 billion
Data from the Human Genome Project revealed that the haploid human nuclear genome comprises approximately 3 billion base pairs of DNA. This extensive genetic sequence contains approximately 20,000 to 25,000 protein-coding genes, with non-coding introns, regulatory elements, and highly repetitive non-coding DNA sequences constituting the majority of the total genome.

59. (B) To sequence all chemical base pairs in human DNA.
The primary goal of the Human Genome Project was to determine the complete chemical sequence of all 3 billion nucleotide base pairs constituting human DNA. Achieving this goal created a reference genome map, enabling scientists to locate human genes, study genetic variation, and advance biomedical research and targeted clinical therapies.

moiety providing the negative charge to the sugar-phosphate backbone of cellular genomic DNA.

101. (A) Uracil (U)
During transcription, RNA polymerase synthesizes an RNA strand complementary to the DNA template strand. Standard Watson-Crick base pairing rules dictate that guanine pairs with cytosine and adenine pairs with uracil in RNA, because ribonucleic acid uses uracil instead of thymine to form two hydrogen bonds with complementary adenine template bases.

102. (D) Cytosine
Cytosine is a single-ring pyrimidine nitrogenous base present in both DNA and RNA. In double-stranded DNA, cytosine forms three complementary hydrogen bonds with guanine. While thymine is restricted to DNA and uracil to RNA, cytosine functions as a universal pyrimidine base across both major classes of cellular nucleic acids.

103. (B) 30%
According to Chargaff's rules for double-stranded DNA, adenine equals thymine and guanine equals cytosine. If adenine comprises 20 percent, then thymine also comprises 20 percent, making 40 percent adenine-thymine pairs. The remaining 60 percent consists of equal amounts of guanine and cytosine, yielding exactly 30 percent guanine in the sample.

104. (C) Ribosome
Ribosomes are non-membrane-bound ribonucleoprotein organelles that act as the structural sites of translation in living cells. Composed of ribosomal RNA and ribosomal proteins organized into small and large subunits, ribosomes decode mRNA codons, position aminoacyl-tRNAs, and catalyze peptidyl transferase peptide bond formation during active polypeptide chain elongation.

105. (B) 2, 1, 4, 3
The standard eukaryotic cell cycle progresses through four distinct phases in sequence. Following mitosis, the cell enters Gap 1 (G1) phase for cell growth, proceeds to Synthesis (S) phase for nuclear DNA replication, enters Gap 2 (G2) phase for pre-mitotic protein synthesis, and culminates in Mitosis (M) phase for nuclear division.

106. (A) Ribozymes
Ribozymes are RNA molecules possessing intrinsic catalytic activity. Unlike traditional protein enzymes, ribozymes use specific tertiary RNA structures to catalyze biochemical reactions, such as phosphodiester cleavage and peptide bond formation. Discoveries of ribozymes like peptidyl transferase support the RNA World hypothesis for early molecular cellular evolution.

107. (B) ATP
Adenosine Triphosphate acts as the universal chemical energy currency of cells. Consisting of an adenine base, ribose sugar, and three phosphate groups, ATP stores energy in high-energy phosphoanhydride bonds. Hydrolysis of the terminal phosphate group to yield ADP releases free energy used to drive endergonic cellular reactions and physiological processes.

108. (B) Exons
Eukaryotic genes are split genes containing coding and non-coding sequences. Exons are the expressible coding segments that remain in mature mRNA after pre-mRNA splicing removes intervening non-coding introns. Exons are joined together end-to-end to form the continuous mature transcript translated into functional protein products at cellular ribosomes.

109. (A) Topoisomerase
As DNA helicase unwinds the double helix during replication, torsional stress and supercoiling build up ahead of the replication fork. Topoisomerase enzymes relieve this torsional strain by introducing transient single-strand or double-strand breaks in the DNA backbone, swiveling or passing strands through, and resealing the phosphodiester bonds smoothly and efficiently.

110. (B) I and III
DNA replication occurs during the S phase of the cell cycle and proceeds strictly in the 5 prime to 3 prime direction. Because synthesis is continuous toward the replication fork, the leading strand requires only a single RNA primer. Conversely, the lagging strand is synthesized discontinuously away from the fork in Okazaki fragments.

111. (D) Monozygotic (identical) twins
Monozygotic twins develop from a single fertilized ovum that splits into two embryos early in development. Because they originate from the identical zygote, monozygotic twins

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chromosome monosomy, and Patau syndrome results from an extra copy of chromosome 13, known as autosomal trisomy 13.

71. (B) Phosphorus-32 and Sulfur-35
Alfred Hershey and Martha Chase used radioactive isotopes to distinguish viral DNA from protein capsids during T2 bacteriophage infection of Escherichia coli. Phosphorus-32 selectively labeled DNA because nucleic acids contain phosphorus but no sulfur, while Sulfur-35 labeled proteins containing methionine and cysteine, conclusively proving that DNA is the true genetic material.

72. (C) Avery, MacLeod, and McCarty
In 1944, Oswald Avery, Colin MacLeod, and Maclyn McCarty biochemically purified Griffith's transforming principle from heat-killed smooth Streptococcus pneumoniae cells. Treating extracts with proteases and RNases failed to prevent transformation, whereas DNase enzymes completely abolished transforming activity, establishing that DNA, not protein or RNA, is the active chemical transforming agent.

73. (D) DNA
Deoxyribonucleic acid serves as the primary hereditary material across virtually all living cellular organisms, storing key instructions required for growth, metabolic development, and cellular function. DNA molecules replicate faithfully prior to cell division and pass genetic traits from parent organisms to offspring, maintaining overall functional continuity across successive biological generations.

74. (A) RNA
Although cellular organisms utilize double-stranded DNA as their hereditary material, several RNA viruses utilize ribonucleic acid as their genetic medium. Examples include Tobacco Mosaic Virus, Human Immunodeficiency Virus, and Influenza virus, which store genetic information in single-stranded or double-stranded RNA genomes and undergo reverse transcription or direct RNA-dependent replication.

75. (A) Isolation of DNA → Restriction Digestion → Gel Electrophoresis → Southern Blotting → Autoradiography
Standard DNA fingerprinting involves five consecutive procedural steps. First, genomic DNA is isolated from cellular samples. Next, restriction endonucleases digest DNA into fragments, which are separated by agarose gel electrophoresis. The separated fragments are transferred to a membrane via Southern blotting and visualized using radiolabeled VNTR probes in autoradiography detection.

76. (B) Walter Sutton and Theodor Boveri
In 1902, Walter Sutton and Theodor Boveri independently formulated the Chromosomal Theory of Inheritance. They noted striking parallels between Mendelian factor segregation and the behavior of chromosomes during meiotic nuclear division, proposing that genes reside at specific loci on chromosomes and that homologous chromosome segregation provides the physical mechanism for Mendelian inheritance.

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77. (A) Law of Segregation
Mendel's Law of Segregation states that two alleles for a heritable character separate during gamete formation, ending up in different gametes. The physical foundation of this law is the separation of homologous chromosome pairs during Anaphase I of meiosis, ensuring each gamete carries only one allele for every gene locus.

78. (C) Cultivation of pest-resistant Bt Cotton
A prominent agricultural application of DNA technology in India is the cultivation of Bt Cotton. Genes encoding endotoxin proteins from the soil bacterium Bacillus thuringiensis are engineered into cotton plants. Expressed Cry toxins protect crops against destructive bollworm pests, significantly increasing agricultural yields while reducing synthetic chemical insecticides.

79. (D) Human Insulin
Recombinant DNA technology enabled the commercial production of human insulin, commercially known as Humulin, in host Escherichia coli bacteria starting in 1978. Recombinant human insulin replaced animal-derived insulin extracted from bovine or porcine pancreas, preventing allergic reactions in diabetic patients and ensuring a scalable, pure supply of life-saving therapeutic hormone.

80. (A) I, II, and III
Applied DNA technology offers diverse practical benefits: DNA fingerprinting resolves disputed paternity cases through genetic profiling, gene therapy targets severe inherited diseases by

CHAPTER 12
Protein Synthesis and Sex Determination

1. The flow of genetic information from DNA to RNA to Protein is referred to as which of the following?
(A) Genetic Recombination
(B) Central Dogma
(C) Reverse Transcription
(D) Gene Regulation

2. Which scientist is credited with proposing the Central Dogma of molecular biology?
(A) Francis Crick
(B) James Watson
(C) Har Gobind Khorana
(D) Gregor Mendel

3. The biological process in which the genetic information encoded in DNA is copied into messenger RNA (mRNA) is called?
(A) Translation
(B) Replication
(C) Transcription
(D) Translocation

4. In some viruses, such as retroviruses, genetic information flows from RNA to DNA. What is this process termed?
(A) Forward Translation
(B) Inverse Replication
(C) Viral Transduction
(D) Reverse Transcription

5. Which cell organelle serves as the primary site for protein synthesis in a cell?
(A) Mitochondria
(B) Lysosome
(C) Ribosome
(D) Golgi apparatus

6. During transcription, which nitrogenous base in RNA pairs with adenine of the DNA template?
(A) Thymine
(B) Uracil
(C) Cytosine
(D) Guanine

7. What is the fundamental role of messenger RNA (mRNA) in protein synthesis?
(A) To supply metabolic energy for peptide bond synthesis
(B) To transport specific amino acids to the ribosome
(C) To act as structural components within ribosomes
(D) To carry genetic information from DNA to ribosomes

8. Which of the following represents the correct standard sequence of the Central Dogma of molecular biology?
(A) DNA → mRNA → Protein
(B) RNA → DNA → Polypeptide
(C) Polypeptide → RNA → DNA
(D) mRNA → DNA → Protein

9. The process of polymerizing amino acids to form a polypeptide chain based on the sequence of codons in mRNA is known as?
(A) Replication
(B) Transcription
(C) Translation
(D) Splicing

10. Which type of RNA acts as an adapter molecule, reading the genetic code and bringing the corresponding amino acid?
(A) tRNA
(B) mRNA
(C) rRNA
(D) snRNA

11. In eukaryotic cells, where does the process of transcription primarily take place?
(A) Cytoplasm
(B) Endoplasmic Reticulum
(C) Plasma Membrane
(D) Nucleus

12. Match List I with List II and select the correct answer:
List I: Type of RNA
P. mRNA
Q. tRNA
R. rRNA
S. snRNA

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phosphate groups in its backbone, whereas the core histone octamer carries a positive charge from basic lysine and arginine residues. This electrostatic force allows DNA to wrap tightly around histones.

91. (A) 22
Human gametes, including sperm cells and ova, are haploid structures generated through meiotic cell division. A normal human sperm cell contains 23 total chromosomes, consisting of 22 autosomes and 1 sex chromosome (either an X or a Y chromosome). During fertilization, these 22 autosomes join 22 maternal autosomes to restore 44 autosomal pairs.

92. (B) The sex chromosome contributed by the sperm.
In humans, biological sex determination is governed by the male gamete. Female ova always carry a single X chromosome. Male sperm cells are heterogametic, with 50 percent bearing an X chromosome and 50 percent bearing a Y chromosome. Fertilization by an X-bearing sperm produces an XX female, whereas a Y-bearing sperm produces an XY male.

93. (A) Kinetochores
Kinetochores are disc-shaped protein assemblies that form on opposite sides of the centromeric DNA region of duplicated chromosomes. During mitosis and meiosis, kinetochores bind directly to spindle microtubules, serving as attachment sites and molecular motors that orchestrate chromosome alignment at the metaphase plate and subsequent sister chromatid segregation toward opposite cellular poles.

94. (C) Sub-metacentric
A sub-metacentric chromosome features a centromere located off-center, slightly displaced from the middle of the chromosomal axis. This asymmetrical placement divides the chromosome into two arms of unequal length: a shorter arm designated as the p arm and a longer arm designated as the q arm, yielding an L-shaped appearance during anaphase movement.

95. (D) Crossing over
Crossing over is the reciprocal exchange of genetic material between non-sister chromatids of paired homologous chromosomes. Occurring during the pachytene stage of meiotic prophase I, this process is mediated by recombination nodules and results in new allele combinations on individual chromatids, generating genetic variation essential for all sexually reproducing biological species.

96. (C) Metaphase
Metaphase is the most suitable phase of the cell cycle for examining chromosome morphology, structure, and total count under a light microscope. During metaphase, chromosomes reach their maximum condensation level and align neatly along the equatorial plane, enabling clear visualization of individual chromatids, centromere locations, and potential structural alterations.

97. (B) Deoxyribonucleic Acid (DNA)
Deoxyribonucleic acid serves as the primary master instructional manual within cellular organisms. Its linear nucleotide sequence encodes structural and regulatory genetic information. Genes contained within genomic DNA are transcribed into messenger RNA, which directs ribosomal machinery to link amino acids in specific sequences, constructing all necessary functional cellular proteins.

98. (C) 3.4 nm
In the classical Watson and Crick B-DNA structural model, one complete 360-degree turn of the double helix spans a pitch distance of 3.4 nanometers (34 Angstroms). Each turn contains approximately 10 base pairs, resulting in a uniform axial distance of 0.34 nanometers between consecutive base pair steps along the axis.

99. (A) Rosalind Franklin and Maurice Wilkins
The double helix model of DNA formulated by Watson and Crick depended critically on high-resolution X-ray diffraction images of DNA fibers produced by Rosalind Franklin and Maurice Wilkins at King's College London. Franklin's famous Photo 51 revealed key helical parameters, including the 2-nanometer diameter, helical pitch, and symmetrical anti-parallel arrangement.

100. (A) P-2, Q-1, R-4, S-3
Nucleic acid components belong to specific biochemical categories. Adenine is a double-ring purine base, cytosine is a single-ring pyrimidine base, deoxyribose is a five-carbon pentose sugar ring, and phosphate represents an inorganic acid

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40. (A) P-3, Q-1, R-2, S-4
Distinct RNA varieties perform specialized biochemical functions in eukaryotic gene expression. Messenger RNA contains genetic codons transcribed from DNA. Transfer RNA decodes these codons to position appropriate amino acids during polypeptide synthesis. Ribosomal RNA integrates into ribosomes to form translational sites, while small nuclear RNA mediates nuclear pre-mRNA splicing operations.

41. (D) A phosphate group
A nucleoside consists strictly of a nitrogenous purine or pyrimidine base covalently attached to a pentose sugar ring via an N-glycosidic bond. A nucleotide is formed when one or more phosphate groups are esterified to the hydroxyl group on the 5 prime carbon of the nucleoside sugar, giving nucleotides their acidic character.

42. (A) Phosphodiester bond
In a single nucleic acid strand, consecutive nucleotides are joined together by strong covalent phosphodiester bonds. This linkage forms between the 3 prime hydroxyl group of one pentose sugar and the phosphate group attached to the 5 prime carbon of the adjacent sugar, building a continuous sugar-phosphate backbone with directional polarity.

43. (B) A DNA sequence coding for a functional product like a protein.
At the molecular level, a gene is defined as a specific functional sequence of nucleotides situated along genomic DNA. It contains regulatory sequences alongside coding regions required to synthesize a functional biological product, which can be either a polypeptide protein or functional non-coding RNA molecules such as ribosomal or transfer RNA.

44. (B) Locus
A gene locus refers to the specific physical location or fixed address that a gene occupies on a given chromosome. Homologous chromosomes share identical gene loci, meaning that corresponding genes reside at matching positions across both parental chromosomes, although different variations of the gene called alleles may occupy those positions.

45. (A) 3, 5, 4, 1, 2
The Central Dogma of molecular biology describes the sequential flow of genetic information inside biological systems. Information originates within genomic DNA, which undergoes transcription to synthesize messenger RNA. The resulting messenger RNA transcript is subsequently decoded through translation at cellular ribosomes to assemble functional amino acid sequences into final operational proteins.

46. (C) Each new DNA helix has one parental strand and one synthesized strand.
Semi-conservative replication dictates that when a double-stranded DNA molecule replicates, the parental strands uncoil and separate, each acting as a template. Every newly formed daughter double helix contains one original conserved parental strand alongside one newly synthesized complementary strand, maintaining accurate genetic inheritance across successive generations of dividing biological cells.

47. (D) DNA Polymerase
DNA polymerase is the key enzyme responsible for synthesizing new DNA strands during replication. It adds complementary deoxyribonucleotides sequentially to the 3 prime hydroxyl terminus of a growing nucleic acid chain. Using single-stranded parental DNA as a template, DNA polymerase ensures high-fidelity replication through its intrinsic proofreading enzyme catalytic activity.

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48. (C) 5' to 3' direction
DNA polymerases strictly require a free 3 prime hydroxyl group to attach incoming deoxyribonucleotides, meaning synthesis occurs exclusively in the 5 prime to 3 prime direction. On the leading strand, unwinding reveals template in a 3 prime to 5 prime orientation, allowing continuous uninterrupted leading strand synthesis toward the advancing replication fork.

49. (B) Okazaki fragments
Because DNA polymerase synthesizes strands only in the 5 prime to 3 prime direction, the lagging strand must be synthesized discontinuously away from the advancing replication fork. This process generates short newly synthesized DNA segments named Okazaki fragments, which are subsequently joined together by DNA ligase to produce a continuous strand.

possess 100 percent identical nuclear genomic DNA sequences and Variable Number of Tandem Repeats, resulting in identical DNA fingerprints that cannot be distinguished by standard profiling.

112. (C) Mitochondria
In addition to nuclear chromosomes, animal cells possess extranuclear DNA contained within mitochondria. Mitochondrial DNA consists of small, circular, double-stranded DNA molecules encoding essential components of the respiratory electron transport chain alongside mitochondrial ribosomal and transfer RNAs. Mitochondrial DNA is inherited maternally through the cytoplasm of the fertilized egg.

113. (B) Haemophilus influenzae (Bacterium)
In 1995, Haemophilus influenzae became the first free-living organism to have its complete genome sequenced. Using a whole-genome shotgun sequencing approach led by Craig Venter and Hamilton Smith, scientists mapped its circular genome of 1.83 million base pairs, marking a historical milestone in modern genomics and computational microbial biology.

114. (D) Inversion
An inversion is a structural chromosomal mutation resulting from two internal double-strand breaks within a single chromosome. The detached chromosomal segment rotates 180 degrees end-to-end before reinserting at the same site. Because genetic material is neither gained nor lost, inversions are balanced rearrangements, though gene expression at breakpoints can be altered.

115. (A) P-3, Q-2, R-1, S-4
Biochemical linkages serve distinct structural roles: phosphodiester bonds link adjacent nucleotides along single nucleic acid strands, hydrogen bonds link complementary base pairs across DNA double strands, N-glycosidic bonds attach nitrogenous bases to pentose sugars, and peptide bonds connect amino acid residues in proteins rather than within nucleic acid polymers.

116. (C) Patau syndrome
Patau syndrome is a severe congenital disorder caused by trisomy 13, resulting in a karyotype of 47 chromosomes. The presence of an extra copy of chromosome 13 disrupts early embryonic development, manifesting in profound intellectual disability, severe neurological defects, microcephaly, cleft lip or palate, polydactyly, and severe congenital heart abnormalities.

117. (A) Heat-killed S strain
In Griffith's bacterial transformation experiment, non-virulent rough (R) strain Streptococcus pneumoniae cells transformed into virulent smooth (S) strain cells by assimilating exogenous DNA released from heat-killed S strain bacteria. This uptake integrated genetic material into the live R strain genome, enabling protective capsule synthesis and restoring full pathogenic virulence.

118. (D) A transgenic or GM crop.
A crop engineered with recombinant DNA technology to express a foreign gene from another organism is defined as a transgenic or genetically modified crop. In arid regions like Rajasthan, agricultural scientists introduce specific genes conferring drought tolerance or osmotic stress resistance into crop plants, developing transgenic lines adapted to harsh environmental conditions.

119. (B) It inhibits spindle formation, inducing polyploidy.
Colchicine is an alkaloid chemical derived from Colchicum autumnale that binds to tubulin dimers, preventing microtubule polymerization and spindle fiber assembly during metaphase. Inhibiting spindle formation prevents sister chromatid segregation to opposite poles during cell division, arresting mitosis and inducing polyploidy by doubling total chromosome numbers in modern plant breeding.

120. (C) Pharmacogenomics (Personalized medicine)
Pharmacogenomics combines pharmacology and genomics to analyze how an individual's genetic profile influences their response to therapeutic drugs. By identifying genetic variations such as single nucleotide polymorphisms affecting drug metabolism and receptor binding, medical professionals tailor drug selections and dosage regimens specifically to optimize efficacy and minimize adverse side effects.

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60. (B) I, II, and IV
Findings from the Human Genome Project demonstrated that less than 2 percent of human DNA encodes proteins, Chromosome 1 contains the highest gene count with 2,968 genes, and 99.9 percent of base pairs are identical across all humans. Repeated sequences actually make up a very large portion of the human genome.

61. (A) Deletion
A deletion is a structural chromosomal aberration involving the loss of a chromosomal segment. When double-strand breaks occur and a fragment breaks away without rejoining, the lost region removes genetic material from that chromosome. This missing sequence can disrupt essential gene functions, frequently causing severe physiological abnormalities or developmental disorders.

62. (C) Translocation
Translocation occurs when a chromosomal segment breaks off and fuses to a non-homologous chromosome. This rearrangement can be reciprocal, where two non-homologous chromosomes exchange fragments, or non-reciprocal. While gene count may remain unchanged in balanced translocations, gene regulation or structure at the fusion breakpoints is often significantly altered or disrupted.

63. (D) Aneuploidy
Aneuploidy is a numerical chromosomal abnormality where an organism gains or loses one or more individual chromosomes relative to the normal diploid number. Common types include monosomy, where one chromosome is missing, and trisomy, where an extra chromosome is present. Aneuploidy typically arises from nondisjunction during meiotic cellular nuclear division.

64. (C) Trisomy of chromosome 21
Down syndrome is caused by trisomy 21, a condition where affected individuals possess three copies of chromosome 21 instead of two, bringing the total chromosome count to 47. This autosomal numerical aberration results from meiotic nondisjunction, leading to physical traits such as facial flattening, hypotonia, and characteristic developmental delays.

65. (B) 45, XO
Turner syndrome is a sex chromosome monosomy disorder in females characterized by a karyotype of 45, XO. Affected individuals have only one functional X chromosome instead of two. Symptoms include short stature, webbed neck, undeveloped ovaries leading to sterility, and absence of secondary sexual characteristics due to reduced estrogen production.

66. (D) Klinefelter syndrome
Klinefelter syndrome is a sex chromosome aneuploidy in males caused by the presence of an extra X chromosome, resulting in a 47, XXY karyotype. Affected individuals develop male phenotypes but exhibit features such as elevated stature, reduced testicle size, sparse body hair, gynaecomastia, and sterility due to significantly impaired testicular spermatogenesis.

67. (A) A broad flat face with a characteristic palmar crease
Children with Down syndrome display distinct physical features caused by trisomy 21. Classic anatomical markers include a broad flat face, epicanthic skin folds at the inner corners of the eyes, a single transverse palmar crease across the palm, short digits, hypotonia, a protruding furrowed tongue, and variable mild to moderate intellectual impairment.

68. (C) Nuclein
In 1869, Swiss physician Friedrich Miescher isolated a unique phosphorous-rich acidic substance from the nuclei of white blood cells harvested from surgical pus bandages. Because this material originated from the cell nucleus, he named it nuclein. Later biochemical studies confirmed that nuclein consisted primarily of deoxyribonucleic acid bound to proteins.

69. (A) Streptococcus pneumoniae
In 1928, Frederick Griffith discovered the bacterial transformation principle using Streptococcus pneumoniae, the bacterium responsible for pneumonia. He experimented with virulent smooth (S) strain and non-virulent rough (R) strain bacteria in mice, demonstrating that heat-killed S strain released a genetic factor that transformed live R strain into pathogenic S strain.

70. (A) P-3, Q-1, R-4, S-2
Human chromosomal disorders stem from distinct numerical abnormalities. Down syndrome involves trisomy of chromosome 21, Klinefelter syndrome is caused by a 47, XXY karyotype, Turner syndrome arises from a 45, XO sex

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List II: Primary Function

1. Structural and catalytic role in ribosomes
2. Carries specific amino acids to ribosomes
3. Involved in splicing of pre-mRNA
4. Carries genetic instructions from DNA

(A) P-4, Q-1, R-2, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-1, Q-2, R-3, S-4

13. Which principal enzyme is responsible for catalyzing the transcription of DNA into RNA?
(A) DNA Polymerase
(B) Helicase
(C) RNA Polymerase
(D) Ligase

14. What is the specific region of DNA called where RNA polymerase binds to initiate transcription?
(A) Terminator
(B) Structural gene
(C) Enhancer
(D) Promoter

15. The sequence of DNA that signals the end of RNA synthesis is known as the?
(A) Terminator
(B) Promoter
(C) Origin of replication
(D) Intron

16. In which direction does RNA polymerase synthesize the new RNA strand?
(A) 3' to 5' direction
(B) 5' to 3' direction
(C) Both 3' to 5' and 5' to 3' simultaneously
(D) N-terminal to C-terminal direction

17. During transcription, the DNA strand with 3' to 5' polarity that acts as a guide for RNA synthesis is called the?
(A) Coding strand
(B) Template strand
(C) Non-template strand
(D) Okazaki strand

18. In eukaryotes, the primary transcript (hnRNA) contains non-coding sequences that must be removed. What are these non-coding sequences called?
(A) Introns
(B) Exons
(C) Promoters
(D) Codons

19. The post-transcriptional process in which introns are removed and exons are joined together is known as?
(A) Capping
(B) Tailing
(C) Splicing
(D) Editing

20. Consider the following statements regarding mRNA:
I. It is formed during the process of translation.
II. It contains codons that dictate the amino acid sequence.
III. In eukaryotes, it undergoes processing before leaving the nucleus.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

21. The relationship between the sequence of nucleotides in mRNA and the sequence of amino acids in a polypeptide is defined as?
(A) Genetic Drift
(B) Genetic Recombination
(C) Genetic Code
(D) Gene Flow

22. How many possible triplet codons are formed by the four nitrogenous bases in the genetic code?
(A) 16
(B) 20
(C) 64
(D) 128

23. Out of the total codons in the standard genetic code, how many actually code for amino acids?
(A) 64
(B) 61
(C) 60
(D) 20

24. A single codon consists of how many adjacent nitrogenous bases?
(A) One
(B) Two
(C) Three
(D) Four

25. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): The genetic code is considered nearly universal.
Reason (R): A specific codon, such as UUU,

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determination
2. Illegal abortion of a female fetus
3. Law to prevent prenatal sex determination
4. Number of females per 1000 males

(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-2, R-4, S-3

119. A father with haemophilia and a mother who is not a carrier have daughters. What will be the genetic status of all their daughters?
(A) Clinically symptomatic haemophilic
(B) Completely normal non-carriers
(C) Lethal phenotype so they will not survive
(D) Carriers of haemophilia

120. The integration of genetics and molecular biology has shown that genetic disorders like haemophilia are fundamentally caused by errors in?
(A) Protein synthesis
(B) Cellular lipid synthesis
(C) Passive cellular osmosis
(D) Complex carbohydrate digestion

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(A) Covalent bonding between their respective sugar-phosphate backbones
(B) Electrostatic repulsion between identical nitrogenous bases
(C) Base pairing between codon and anticodon
(D) Ionic bonding mediated specifically by calcium ions

38. The actual three-dimensional structure of a tRNA molecule looks like an inverted version of which letter?
(A) S
(B) L
(C) U
(D) O

39. What molecule is utilized as the primary energy source for the aminoacylation of tRNA?
(A) AMP
(B) ADP
(C) CMP
(D) ATP

40. Consider the following statements regarding the genetic code:
I. It is an overlapping code.
II. It is read in a contiguous manner without commas.
III. UAA, UAG, and UGA are chain termination codons.
Which of the above statements is/are incorrect?
(A) I only
(B) II only
(C) III only
(D) I and II only

41. Which type of RNA forms the largest percentage of total cellular RNA?
(A) mRNA
(B) tRNA
(C) rRNA
(D) snRNA

42. Match List I with List II and select the correct answer:
List I: Translation Component
P. Peptidyl transferase
Q. Aminoacyl-tRNA synthetase
R. Release factor
S. Initiation factor
List II: Role
1. Helps in binding of ribosome to mRNA
2. Catalyzes peptide bond formation
3. Binds to stop codon to terminate translation
4. Charges tRNA with an amino acid
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

43. A ribosome is composed of two subunits. What are the subunits of a eukaryotic 80S ribosome?
(A) 50S and 30S
(B) 60S and 40S
(C) 40S and 40S
(D) 70S and 10S

44. What are the two subunits of a prokaryotic 70S ribosome?
(A) 50S and 30S
(B) 60S and 40S
(C) 40S and 30S
(D) 50S and 20S

45. In addition to a structural role, rRNA also acts as an enzyme in translation. What is an RNA molecule with catalytic activity called?
(A) Protease
(B) Lipase
(C) Ribozyme
(D) Transferase

46. Multiple ribosomes simultaneously translating a single mRNA molecule form a structure known as?
(A) Nuclear nucleosome complex
(B) Pre-mRNA spliceosome complex
(C) Cytoplasmic centrosome organelle
(D) Polyribosome

47. Which of the following is NOT a property of tRNA?
(A) It is a linear strand without loops
(B) It contains a specific anticodon loop for codon recognition
(C) It possesses a three-prime amino acid acceptor end
(D) It acts as a crucial adapter molecule during translation

48. During translation, the peptide bond is formed between which two chemical groups of adjacent amino acids?
(A) Hydroxyl group and Carboxyl group
(B) Carboxyl group and Amino group
(C) Amino group and Phosphate group
(D) Methyl group and Hydroxyl group

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but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

96. Because males have only one copy of the X chromosome, a recessive mutant gene on the X chromosome will always express itself. This condition is termed?
(A) Homozygous
(B) Hemizygous
(C) Heterozygous
(D) Nullizygous

97. The pattern of inheritance where a trait is passed from a father to his grandson through his daughter is called?
(A) Non-Mendelian inheritance
(B) Criss-cross inheritance
(C) Maternal inheritance
(D) Co-dominance

98. Colour blindness in humans is an example of which type of genetic disorder?
(A) X-linked recessive
(B) Autosomal dominant
(C) Autosomal recessive
(D) Y-linked dominant

99. Which specific defect does a person suffering from red-green colour blindness experience?
(A) Total and complete inability to perceive any colours
(B) Severe blurring and impairment of vision at night
(C) Difficulty distinguishing red and green
(D) Inability to clearly see distant objects at a distance

100. Consider the following statements regarding sex determination in humans:
I. A male child receives his Y chromosome from his father.
II. A female child receives an X chromosome from both parents.
III. The mother determines whether the offspring will be male or female.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

101. Why are X-linked recessive disorders like colour blindness more common in males than in females?
(A) Males have two X chromosomes, increasing the chance of mutation.
(B) The Y chromosome carries dominant alleles that cause the disorder.
(C) Males need only one mutant allele to express the disorder.
(D) Females do not possess genes for colour vision.

102. Match List I with List II and select the correct answer:
List I: Genetic Concept
P. Colour blindness
Q. Haemophilia
R. Carrier female
S. Hemizygous condition
List II: Description
1. X-linked recessive bleeding disorder
2. Has one normal and one mutant X chromosome
3. Defect in red-green cone cells
4. Presence of only one X chromosome in males
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-3, S-2

103. If a normal woman marries a colour-blind man, what will be the visual status of their sons?
(A) All sons will be colour-blind
(B) 50% of sons will be colour-blind
(C) All sons will have normal vision
(D) 25% of sons will be colour-blind

104. Haemophilia is a genetic disorder characterized by?
(A) Failure of blood to clot properly
(B) Pathological and excessive internal iron build-up
(C) Complete inability to distinguish primary colours
(D) Rapid and premature breakdown of red blood cells

105. Haemophilia is historically referred to as the "Royal Disease" because it affected descendants of which prominent historical figure?
(A) Napoleon Bonaparte
(B) Alexander the Great
(C) Queen Victoria
(D) King Tutankhamun

106. In Haemophilia A, a mutation prevents the synthesis of which essential protein?
(A) Factor VIII

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(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

61. Gene expression at the cellular level is primarily manifested through the synthesis of which biomolecules?
(A) Carbohydrates
(B) Lipids
(C) Proteins
(D) Vitamins

62. Many proteins synthesized by cells function as biological catalysts. What are these called?
(A) Hormones
(B) Antibodies
(C) Antigens
(D) Enzymes

63. Insulin is a molecule synthesized in the body that regulates blood sugar. Chemically, insulin is a?
(A) Peptide hormone
(B) Complex structural carbohydrate
(C) Hydrophobic steroid lipid
(D) High molecular weight nucleic acid

64. A mutation involving a change in a single base pair of DNA is termed a?
(A) Chromosomal aberration
(B) Point mutation
(C) Frameshift mutation
(D) Genomic mutation

65. Arrange the following stages of the translation process in the correct order:
I. Translocation of the ribosome
II. Binding of mRNA to the small ribosomal subunit
III. Release of the newly formed polypeptide
IV. Peptide bond formation
(A) II, IV, I, III
(B) II, I, IV, III
(C) IV, II, I, III
(D) I, II, III, IV

66. Insertion or deletion of a single nucleotide in a coding region causes the reading frame of the codons to shift. This is known as a?
(A) Frameshift mutation
(B) Silent mutation
(C) Nonsense mutation
(D) Substitution mutation

67. A mutation that changes a codon coding for an amino acid into a stop codon, resulting in premature termination of the protein, is called a?
(A) Missense mutation
(B) Silent mutation
(C) Nonsense mutation
(D) Reverse mutation

68. Which genetic disorder is caused by a point mutation that changes the amino acid glutamic acid to valine in the beta-globin chain of hemoglobin?
(A) Severe Hemophilia A
(B) Red-green colour blindness
(C) Alpha-thalassemia disorder
(D) Sickle cell anemia

69. The knowledge of protein synthesis has broad applications in Biotechnology. Which of the following is produced using recombinant DNA technology and bacterial translation machinery?
(A) Industrial synthetic nylon
(B) Refined table salt
(C) Human insulin
(D) Commercial polyethylene

70. How do mutations in DNA primarily cause genetic disorders?
(A) By systematically destroying functional ribosomal subunits within the cell
(B) By altering mRNA sequences to produce defective proteins
(C) By directly converting double-stranded DNA into proteins
(D) By permanently inhibiting cellular ATP production pathways

71. If a mutation changes a codon but it still codes for the same amino acid due to the degeneracy of the genetic code, it is termed a?
(A) Lethal mutation
(B) Frameshift mutation
(C) Nonsense mutation
(D) Silent mutation

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72. Match List I with List II and select the correct answer:
List I: Type of Mutation
P. Silent mutation
Q. Missense mutation
R. Nonsense mutation
S. Frameshift mutation
List II: Effect on Protein Synthesis

49. Which of the following best describes the first phase of translation?
(A) Sequential elongation of the polypeptide chain
(B) Activation and charging of tRNA
(C) Binding of the termination release factor
(D) Post-transcriptional splicing of pre-mRNA

50. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): The process of translation generally cannot begin without the codon AUG.
Reason (R): AUG is the initiation codon that directs the ribosome to begin protein synthesis.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

51. The ribosome possesses two main binding sites for tRNA molecules during elongation. What are they commonly called?
(A) M-site and N-site
(B) X-site and Y-site
(C) P-site and A-site
(D) D-site and T-site

52. The movement of the ribosome along the mRNA molecule from one codon to the next is termed?
(A) Transformation
(B) Transcription
(C) Transition
(D) Translocation

53. Which direction does the ribosome read the mRNA during translation?
(A) 3' to 5'
(B) 5' to 3'
(C) N-terminus to C-terminus
(D) C-terminus to N-terminus

54. The synthesis of a polypeptide chain proceeds in which direction?
(A) From C-terminus to N-terminus
(B) From N-terminus to C-terminus
(C) From 5' to 3'
(D) From 3' to 5'

55. What happens when a stop codon reaches the A-site of the ribosome?
(A) A specific suppressor tRNA brings a stop amino acid
(B) The entire ribosomal complex reverses reading direction
(C) RNA polymerase enzyme detaches completely from DNA
(D) A release factor binds, terminating translation

56. What happens to the mRNA molecule after the completion of translation?
(A) It is eventually degraded by ribonucleases
(B) It is permanently stored in the ribosome
(C) It is converted back into DNA
(D) It is transformed into a tRNA molecule

57. The regions of mRNA before the start codon and after the stop codon that are not translated are called?
(A) Non-coding intron sequences
(B) Transcriptional promoter regions
(C) Untranslated regions
(D) Transcriptional enhancer elements

58. Match List I with List II and select the correct answer:
List I: Translation Term
P. A-site
Q. P-site
R. E-site
S. mRNA binding site
List II: Description
1. Holds the growing polypeptide chain
2. Exit site for uncharged tRNA
3. Located on the smaller ribosomal subunit
4. Accepts the incoming charged tRNA
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

59. Which of the following environmental requirements is crucial for the stability of the ribosomal subunits joining together during initiation?
(A) Exceptionally high incubation temperature
(B) Complete absence of molecular oxygen
(C) Presence of ferrous Iron ions (Fe_2+)
(D) Presence of $Mg^{2+}+$ ions

60. Consider the following statements regarding Translation:
I. It occurs in the nucleus of a eukaryotic cell.
II. It is an energy-consuming process.
III. Peptidyl transferase is the enzyme that forms peptide bonds.
Which of the above statements is/are correct?

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(A) Mother
(B) Both mother and father equally
(C) Environmental factors
(D) Father

85. Arrange the following events of sex determination and reproduction in the correct sequence:
I. Fertilization of ovum by sperm
II. Formation of X and Y bearing sperms
III. Development of XX or XY zygote
IV. Meiosis in male testes
(A) IV, II, I, III
(B) II, IV, I, III
(C) I, II, III, IV
(D) IV, I, II, III

86. What is the probability of a human couple having a female child during any given pregnancy?
(A) 25%
(B) 50%
(C) 75%
(D) 100%

87. An ovum produced by a normal human female always carries which sex chromosome?
(A) Y chromosome
(B) Both X and Y chromosomes
(C) No sex chromosomes
(D) Only X chromosome

88. Match List I with List II and select the correct answer:
List I: Chromosomal Complement
P. 44 Autosomes + XX
Q. 44 Autosomes + XY
R. 22 Autosomes + X
S. 22 Autosomes + Y
List II: Biological Condition in Humans
1. Normal Male somatic cell
2. Normal Female somatic cell
3. Sperm carrying male determinant
4. Ovum or Sperm carrying female determinant
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-3, S-4
(D) P-4, Q-3, R-2, S-1

89. If a sperm carrying a Y chromosome fertilizes an ovum, what will be the sex of the resulting zygote?
(A) Female
(B) Cannot be determined
(C) Male
(D) Intersex

90. Which specific gene located on the Y chromosome is primarily responsible for triggering male development in humans?
(A) SRY gene
(B) BRCA1 gene
(C) Hemophilia gene
(D) Color vision gene

91. In terms of size, how does the Y chromosome generally compare to the X chromosome in humans?
(A) It is much larger than the X chromosome
(B) It is equal in size to the X chromosome
(C) It is much smaller than the X chromosome
(D) It varies depending on age

92. Identify the incorrect statement regarding human sex chromosomes:
(A) Normal human females possess two identical X chromosomes.
(B) The X chromosome contains fewer genes than Y.
(C) Normal human males have one X and one Y chromosome.
(D) Male sperms can carry either an X or a Y chromosome.

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93. What is the ratio of X-bearing sperms to Y-bearing sperms produced during normal spermatogenesis in males?
(A) 1:2
(B) 2:1
(C) 1:1
(D) 3:1

94. Genes that are present on the X chromosome but lack corresponding alleles on the Y chromosome are known as?
(A) Autosomal genes
(B) Mitochondrial genes
(C) Multiple alleles
(D) Sex-linked genes

95. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): In humans, the sex of the newborn is determined by the father and not by the mother.
Reason (R): Females produce only one type of gamete (carrying X), while males produce two types of gametes (carrying X or Y).
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true

1. Changes entire downstream amino acid sequence
2. No change in the amino acid sequence
3. Results in a premature stop codon
4. Replaces one amino acid with another

(A) P-2, Q-4, R-3, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-4, Q-2, R-1, S-3

73. Which type of bond is responsible for holding the primary structure of a protein together after translation?
(A) Hydrogen bond
(B) Disulfide bond
(C) Peptide bond
(D) Phosphodiester bond

74. Many broad-spectrum antibiotics work by inhibiting which cellular process in bacteria?
(A) Protein synthesis
(B) Oxygenic photosynthesis
(C) Cellular lipid synthesis
(D) Anaerobic glycolysis

75. Given below are two statements: an Assertion (A) and a Reason (R).
Assertion (A): A single nucleotide change in a gene can completely alter the function of the corresponding protein.
Reason (R): The genetic code is read in triplets, and changing one base can either change the amino acid or introduce a stop codon.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

76. In humans, the total number of chromosomes in a normal somatic cell is?
(A) 23
(B) 44
(C) 46
(D) 48

77. Out of the 23 pairs of chromosomes in humans, how many pairs are autosomes?
(A) 1 pair
(B) 22 pairs
(C) 23 pairs
(D) 46 pairs

78. Which pair of chromosomes is responsible for determining the biological sex of a human?
(A) Non-sex autosomes
(B) Homologous pair autosomes
(C) Extranuclear mitochondrial DNA
(D) Sex chromosomes

79. The sex chromosome complement of a normal human female is?
(A) XX
(B) XY
(C) XO
(D) XXY

80. Consider the following statements regarding Gene Expression:
I. It involves both transcription and translation.
II. All genes in a cell are continuously expressed at all times.
III. Gene expression results in the formation of functional proteins or RNAs.
Which of the above statements is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

81. The sex chromosome complement of a normal human male is?
(A) XX
(B) XY
(C) YY
(D) XO

82. Which of the following represents the correct hierarchical order from the smallest to the largest genetic unit?
(A) Nucleotide → Codon → Gene → Chromosome
(B) Chromosome → Gene → Nucleotide → Codon
(C) Codon → Nucleotide → Chromosome → Gene
(D) Gene → Chromosome → Codon → Nucleotide

83. Because human males produce two different types of gametes (one carrying X and the other carrying Y), they are referred to as?
(A) Homogametic
(B) Isogametic
(C) Heterogametic
(D) Parthenogenetic

84. Which biological parent is responsible for determining the sex of a child in humans?

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(B) Oxygen-carrying hemoglobin
(C) Pancreatic hormone insulin
(D) Muscle filament protein myosin

107. A female who is heterozygous for the Haemophilia gene (XHXh) is clinically normal but can pass the gene to her offspring. She is known as a?
(A) Patient
(B) Hemizygote
(C) Sufferer
(D) Carrier

108. Which of the following is NOT a sex-linked disorder?
(A) Red-green colour blindness
(B) Sickle cell anemia
(C) Haemophilia
(D) Duchenne muscular dystrophy

109. If a carrier woman for Haemophilia marries a normal man, what is the probability that their son will be haemophilic?
(A) 0%
(B) 25%
(C) 50%
(D) 100%

110. The biological defect in colour blindness represents a failure in the proper synthesis of functional proteins in which cells of the eye?
(A) Rod cells
(B) Cornea cells
(C) Lens cells
(D) Cone cells

111. What is the full form of the Indian law PCPNDT Act, enacted to curb female foeticide?
(A) Pre-Conception and Pre-Natal Diagnostic Techniques Act
(B) Post-Conception and Pre-Natal Disease Treatment Act
(C) Pre-Childbirth and Pregnancy Diagnosis Techniques Act
(D) Post-Childbirth and Pre-Natal Detection Techniques Act

112. The PCPNDT Act explicitly bans which of the following practices in medical clinics?
(A) Routine ultrasound scans for monitoring fetal growth
(B) Disclosure of fetal sex to parents
(C) Diagnostic detection of chromosomal abnormalities
(D) Routine nutritional counseling for pregnant women

113. Amniocentesis is a technique medically designed for detecting genetic disorders, but it has often been misused for?
(A) Curing genetic diseases
(B) Pre-natal sex determination
(C) Increasing fetal growth rate
(D) Determining the blood group of the mother

114. The term "Sex Ratio" is demographically defined as?
(A) The number of females per 1000 males in a population
(B) The number of males per 1000 females in a population
(C) The number of births per 1000 people
(D) The percentage of females in the total population

115. According to the 2011 Census, what is the general sex ratio (females per 1000 males) of Rajasthan?
(A) 943
(B) 928
(C) 890
(D) 914

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116. An imbalance in the sex ratio, specifically a declining number of females, primarily leads to which of the following social issues?
(A) Rapid overpopulation and overcrowding
(B) Sustainable long-term economic boom
(C) Significant decrease in overall demographic mortality rates
(D) Rise in gender violence and trafficking

117. Social awareness campaigns regarding sex determination primarily aim to?
(A) Actively encourage families to have only male children
(B) Promote widespread use of amniocentesis for family planning
(C) Eradicate female foeticide and promote equality
(D) Strictly restrict the total number of children per family

118. Match List I with List II and select the correct answer:
List I: Social Term/Act
P. PCPNDT Act
Q. Sex Ratio
R. Female Foeticide
S. Amniocentesis
List II: Context
1. Diagnostic technique often misused for sex

codes for the same amino acid (Phenylalanine) in almost all organisms from bacteria to humans.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

26. Which of the following codons functions as the universal start codon in most organisms?
(A) AUG
(B) UAA
(C) UGA
(D) UAG

27. The start codon AUG codes for which of the following amino acids?
(A) Valine
(B) Serine
(C) Glycine
(D) Methionine

28. Match List I with List II and select the correct answer:
List I: Feature of Genetic Code
P. Degenerate
Q. Unambiguous
R. Commaless
S. Universal
List II: Description
1. Read in a continuous fashion without punctuations
2. Same code applies to almost all living organisms
3. One amino acid can be coded by more than one codon
4. One codon codes for only one specific amino acid
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-2, R-3, S-4

29. The property of the genetic code where a single amino acid is coded by multiple different codons is known as?
(A) Universality
(B) Unambiguity
(C) Degeneracy
(D) Overlapping

30. Which of the following is NOT one of the three standard stop codons?
(A) UAA
(B) UAG
(C) UGA
(D) UAC

31. Stop codons are also known as nonsense codons because they?
(A) Do not code for an amino acid
(B) Code exclusively for rare amino acids
(C) Cause frameshift mutations in DNA
(D) Direct the destruction of mRNA molecules

32. Which scientist played a crucial role in deciphering the genetic code by synthesizing RNA molecules with defined sequences?
(A) Charles Darwin
(B) Marshall Nirenberg
(C) Louis Pasteur
(D) Robert Hooke

33. The genetic code is unambiguous. This implies that?
(A) All individual amino acids have only one codon
(B) One codon codes for one amino acid
(C) The nucleotide code can be read in reverse
(D) The continuous code contains punctuation marks

34. Where is the anticodon sequence located?
(A) On the tRNA molecule
(B) On the mRNA molecule
(C) On the rRNA molecule
(D) On the DNA template strand

35. Arrange the following events of gene expression in the correct chronological order:
I. Binding of mRNA to the ribosome
II. Transcription of DNA into primary transcript
III. Post-transcriptional modification (splicing)
IV. Elongation of the polypeptide chain
(A) II, III, I, IV
(B) I, II, III, IV
(C) II, I, III, IV
(D) III, II, I, IV

36. The process of attaching an amino acid to its corresponding tRNA is known as?
(A) Enzymatic transcription of DNA
(B) Post-transcriptional RNA splicing
(C) Ribosomal peptide bond formation
(D) Aminoacylation of tRNA

37. What defines the specific interaction between mRNA and tRNA during translation?

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ANSWERS

1. (B) Central Dogma
The flow of genetic information within a biological system follows a directional pathway from nucleic acids to functional molecules. In molecular biology, this fundamental concept explains how genetic code stored in deoxyribonucleic acid is transcribed into messenger ribonucleic acid and subsequently translated into functional protein chains necessary for cellular structures and metabolic activities.

2. (A) Francis Crick
In 1958, Francis Crick formally articulated the framework governing the transfer of sequential information in living organisms. His proposal established that genetic information moves irreversibly from nucleic acid sequences to amino acid sequences in proteins, providing a foundational framework for understanding gene expression, cellular replication, and molecular inheritance mechanisms across diverse biological organisms.

3. (C) Transcription
Transcription represents the initial stage of gene expression where a specific DNA segment is copied into a complementary RNA strand by RNA polymerase. This process converts stored genomic instructions into portable messenger molecules capable of leaving the genomic locus, allowing cells to synthesize required functional polypeptides in accordance with cellular signaling and metabolic demands.

4. (D) Reverse Transcription
Certain biological entities, particularly retroviruses like HIV, utilize a unique enzymatic mechanism to synthesize complementary DNA from a single-stranded RNA genome. Catalyzed by reverse transcriptase, this backward flow of genetic information enables viral genetic material to integrate seamlessly into the host cell genome, overriding standard cellular flow and facilitating persistent intracellular viral replication.

5. (C) Ribosome
Ribosomes are complex ribonucleoprotein structures present within all living cells that carry out protein synthesis. Acting as molecular factories, they read nucleotide sequences carried by messenger RNA molecules and catalyze the formation of peptide bonds between incoming amino acids, thereby assembling functional polypeptide chains required for structural integrity and enzymatic activity in organisms.

6. (B) Uracil
During RNA synthesis, specific base-pairing rules dictate nucleotide incorporation opposite the DNA template strand. While DNA utilizes thymine to pair with adenine, RNA replaces thymine with uracil. Consequently, whenever RNA polymerase encounters an adenine residue on the DNA template, it incorporates a uracil nucleotide into the growing complementary RNA sequence during transcription processes.

7. (D) To carry genetic information from DNA to ribosomes
Messenger RNA serves as an intermediary carrier molecule during gene expression. Synthesized from genomic DNA templates within the cell nucleus or nucleoid region, it conveys encoded genetic instructions directly to cytoplasmic ribosomes. This transfer ensures that ribosomal machinery receives precise nucleotide sequences necessary for directing correct amino acid assembly into functional cellular proteins.

8. (A) DNA → mRNA → Protein
The classical pathway of gene expression follows a sequential vector in living systems. Genomic DNA undergoes transcription to produce messenger RNA, which subsequently undergoes translation at ribosomal complexes to form functional proteins. This standard directional sequence maintains fidelity during cellular information transfer, ensuring that inherited genetic instructions accurately manifest as functional cellular and structural proteins.

9. (C) Translation
Translation is the biochemical process wherein genetic code conveyed by messenger RNA is decoded into specific amino acid sequences. Operating on ribosomal complexes, transfer RNA molecules decode successive nucleotide triplets and supply corresponding amino acids,

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chain that typically lacks normal biological function or undergoes rapid intracellular degradation.

68. (D) Sickle cell anemia
Sickle cell anemia is a hereditary blood disorder caused by a specific point mutation in the beta-globin gene. A single nucleotide substitution changes the sixth codon from GAG to GUG, substituting hydrophilic glutamic acid with hydrophobic valine. This structural change causes hemoglobin molecules to polymerize under low oxygen, distorting red blood cells.

69. (C) Human insulin
Recombinant DNA technology utilizes fundamental knowledge of genetic code universality and protein synthesis to produce therapeutic proteins. By inserting the human insulin gene into bacterial plasmids, bioengineered bacteria express, transcribe, and translate the gene using their cellular machinery, yielding bioidentical human insulin at commercial scales to treat diabetes mellitus effectively.

70. (B) By altering mRNA sequences to produce defective proteins
Mutations alter genomic DNA sequences, which are subsequently copied into messenger RNA during transcription. These altered mRNA transcripts present modified codon arrangements to translation machinery, leading to misfolded, truncated, or non-functional proteins. Malfunctioning or absent proteins disrupt essential metabolic pathways and structural integrity, giving rise to clinical manifestations of genetic disorders.

71. (D) Silent mutation
A silent mutation occurs when a nucleotide change in a gene alters a triplet codon to another codon that specifies the exact same amino acid, owing to degeneracy in the genetic code. Because the resulting polypeptide chain retains an identical amino acid sequence, protein structure and cellular function remain completely unaffected by the mutation.

72. (A) P-2, Q-4, R-3, S-1
Mutations exert varied effects on translation products. Silent mutations cause no change in amino acid sequence. Missense mutations substitute one amino acid for another in the polypeptide. Nonsense mutations introduce premature stop codons halting synthesis. Frameshift mutations insert or delete bases, completely altering all downstream triplet codons and amino acid sequences.

73. (C) Peptide bond
The primary structure of a protein refers to the linear sequence of amino acids joined together during translation. These amino acid residues are held together by covalent peptide bonds formed between alpha-carboxyl and alpha-amino groups. This robust backbone maintains sequence integrity before higher-order secondary, tertiary, or quaternary protein folding occurs.

74. (A) Protein synthesis
Many broad-spectrum antibiotics exert antibacterial activity by selectively targeting and disrupting bacterial protein synthesis. Because prokaryotic 70S ribosomes differ structurally from eukaryotic 80S ribosomes, compounds like tetracyclines, erythromycin, and aminoglycosides specifically inhibit bacterial translation steps without causing cellular toxicity in human host tissues during clinical infection treatment.

75. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
A single nucleotide substitution in a gene can fundamentally change protein function. Because genetic code is decoded in consecutive triplet codons, altering one base can substitute an critical amino acid or introduce a stop codon, altering higher-order protein folding and active site conformation, confirming that the reason fully explains the assertion.

76. (C) 46
Human somatic cells are diploid, containing a total complement of 46 chromosomes organized into 23 homologous pairs within the nucleus. This karyotype comprises 22 pairs of autosomes regulating general physiological traits and one pair of sex chromosomes responsible for sex determination, ensuring chromosomal stability across cell divisions via mitotic replication.

77. (B) 22 pairs
Among the 23 total chromosome pairs present in human somatic cells, exactly 22 pairs are classified as autosomes. These autosomal pairs are morphologically identical in both biological males and females, containing genes that encode structural proteins, metabolic enzymes, and

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RNA molecules within the cell nucleus prior to export and cytoplasmic translation.

19. (C) Splicing
RNA splicing is a critical nuclear post-transcriptional modification process in eukaryotic gene expression. Catalyzed by large ribonucleoprotein complexes called spliceosomes, this mechanism precisely cuts and removes non-coding intron sequences from precursor messenger RNA transcripts while simultaneously ligating remaining coding exon sequences together to construct a mature, functional mRNA molecule ready for cytosolic translation.

20. (B) II and III only
Messenger RNA is synthesized during transcription, not translation, establishing statement one as incorrect. Statement two is correct because mRNA contains triplet codons that dictate specific amino acid sequences. Statement three is also correct, as eukaryotic precursor mRNA undergoes extensive post-transcriptional modifications including capping, splicing, and polyadenylation inside the nucleus prior to cytoplasmic translation.

21. (C) Genetic Code
The genetic code represents the universal dictionary translating nucleotide sequences in nucleic acids into functional amino acid sequences in proteins. Composed of specific triplet codon combinations of adenine, uracil, cytosine, and guanine, this biochemical coding system governs how genetic information stored in messenger RNA determines the primary structural composition of polypeptides during ribosomal translation.

22. (C) 64
Biological genetic code relies on triplet nucleotide combinations derived from four distinct nitrogenous bases. Calculating the total permutation mathematically yields four raised to the third power, resulting in exactly sixty-four possible triplet codons. This comprehensive set of sixty-four codons accounts for specifying all twenty standard amino acids as well as dedicated translation start and stop signaling codes.

23. (B) 61
Among the sixty-four total triplet codons present in the standard genetic code, exactly sixty-one function as sense codons that directly specify individual amino acids. The remaining three codons serve strictly as stop signals that terminate polypeptide synthesis. Thus, sixty-one codons actively participate in mapping nucleotide sequences to corresponding amino acids during ribosomal translation processes.

24. (C) Three
A codon is defined as a contiguous sequence of three adjacent nitrogenous bases situated on a messenger RNA molecule. Because four available bases combined in pairs would only yield sixteen combinations—insufficient for twenty amino acids—a triplet arrangement providing sixty-four possibilities ensures adequate coding capacity for directing precise amino acid incorporation during protein assembly.

25. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
The genetic code demonstrates near-universal conservation across virtually all biological organisms. A given triplet codon specifies the exact same amino acid whether expressed in simple prokaryotic bacteria or complex eukaryotic human cells, demonstrating conserved evolutionary origin. Therefore, the reason provided accurately explains why the genetic code is regarded as universal throughout biological systems.

26. (A) AUG
The nucleotide triplet AUG serves as the universal start codon across prokaryotic and eukaryotic organisms. During translation initiation, the small ribosomal subunit recognizes AUG on messenger RNA, establishing the correct reading frame for polypeptide synthesis. Additionally, AUG specifies the amino acid methionine, which typically forms the first N-terminal residue of newly synthesized proteins.

27. (D) Methionine
The initiation codon AUG plays a dual role in protein synthesis. Beyond establishing the starting point and reading frame for ribosomal translation along messenger RNA, AUG explicitly encodes the sulfur-containing amino acid methionine. Consequently, newly synthesized polypeptide chains initially incorporate methionine at their N-terminus before potential post-translational enzymatic processing removes or modifies it.

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includes a distinct anticodon loop and a three-prime acceptor stem, enabling essential adapter functions during translation.

48. (B) Carboxyl group and Amino group
Peptide bond formation involves a condensation reaction linking adjacent amino acid residues during translation. The catalytic ribosomal subunit joins the free carboxyl group belonging to the amino acid on peptidyl-tRNA with the alpha-amino group of the newly arrived amino acid on aminoacyl-tRNA, releasing a water molecule and elongating the polypeptide chain.

49. (B) Activation and charging of tRNA
Before translation elongation can proceed on ribosomes, individual amino acids must undergo activation in the cytoplasm. This initial phase involves attaching specific amino acids to their cognate tRNA molecules via high-energy ester bonds in an ATP-dependent reaction. Charged tRNAs then supply activated amino acids directly to the ribosomal translation complex during protein synthesis.

50. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Protein synthesis requires a precise starting landmark along messenger RNA. The AUG codon acts universally as this initiation signal, recognized specifically by initiator transfer RNA carrying methionine. Without AUG, translation initiation complexes cannot assemble correctly to set the proper reading frame, confirming that the reason accurately justifies why AUG is essential for translation initiation.

51. (C) P-site and A-site
During elongation, the large ribosomal subunit contains two functional tRNA binding cavities: the peptidyl site (P-site) and aminoacyl site (A-site). The P-site retains the tRNA attached to the growing polypeptide chain, while the A-site accepts incoming charged tRNAs matching next mRNA codons, facilitating peptide bond transfer and chain extension.

52. (D) Translocation
Translocation refers to the coordinated step-by-step movement of the ribosome along a messenger RNA strand during translation elongation. Powered by GTP hydrolysis, the ribosome advances by exactly one triplet codon toward the three-prime end, shifting uncharged tRNA to the exit site and peptidyl-tRNA from the A-site to the P-site continuously.

53. (B) 5' to 3'
Ribosomes read messenger RNA strictly in the five-prime to three-prime direction during protein translation. Beginning at the start codon near the five-prime end, the ribosomal translation complex moves incrementally toward the three-prime end, sequentially decoding triplet codons and linking corresponding amino acids until encountering a stop codon near the three-prime untranslated region.

54. (B) From N-terminus to C-terminus
Polypeptide chain assembly follows a defined chemical directionality during protein translation. Synthesis starts with the free amino group of the first amino acid at the N-terminus and proceeds sequentially by adding new amino acids to the free carboxyl group at the growing C-terminus, resulting in linear protein growth from N-terminus to C-terminus.

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55. (D) A release factor binds, terminating translation
When a stop codon occupies the ribosomal A-site during translation, no complementary aminoacyl-tRNA recognizes the sequence. Instead, protein release factors bind directly to the stop codon, triggering peptidyl transferase to hydrolyze the ester bond linking the completed polypeptide to tRNA, thereby releasing the newly synthesized protein and disassembling the ribosomal complex.

56. (A) It is eventually degraded by ribonucleases
Following translation, messenger RNA molecules possess finite lifespan inside cellular environments. Once their protein synthesis rounds are complete, specialized cellular enzymes called ribonucleases hydrolyze the phosphodiester backbone of mRNA. This controlled degradation recycles nucleotides and prevents persistent overexpression of specific proteins, allowing dynamic regulation of cellular metabolism.

57. (C) Untranslated regions
Untranslated regions, abbreviated as UTRs, are non-coding RNA segments positioned flanking the protein-coding sequence on messenger RNA. Located at both five-prime and three-prime ends, these sequences are not translated into amino acids but play crucial regulatory roles

38. (B) L
While transfer RNA molecules fold into a two-dimensional cloverleaf pattern due to internal base pairing, their actual resolved three-dimensional tertiary structure resembles an inverted capital letter L. This compact structure positioning the anticodon loop at one end and the amino acid acceptor stem at the opposite end fits precisely into ribosomal binding sites.

39. (D) ATP
The aminoacylation of transfer RNA requires chemical energy to activate free amino acids before attachment. Adenosine triphosphate provides this required energy through enzymatic hydrolysis, forming an intermediate aminoacyl-AMP complex and releasing inorganic pyrophosphate. This energizes the amino acid, allowing aminoacyl-tRNA synthetase to transfer it directly onto the three-prime hydroxyl terminus of tRNA.

40. (A) I only
Statement one is incorrect because the genetic code is non-overlapping, meaning adjacent nucleotide triplets are read sequentially without sharing bases between successive codons. Statement two is correct as the code is commaless and read contiguously. Statement three is also correct because UAA, UAG, and UGA function universally as chain termination signals during protein translation.

41. (C) rRNA
Ribosomal RNA constitutes the vast majority of total cellular RNA, accounting for roughly eighty percent of all RNA present within active cells. This high abundance stems from the continuous cellular demand for ribosomes, which are essential structural and catalytic complexes required to maintain active protein synthesis pathways throughout cell survival and growth phases.

42. (A) P-2, Q-4, R-3, S-1
Translation requires distinct molecular components acting in coordination. Peptidyl transferase catalyzes peptide bond formation between adjacent amino acids. Aminoacyl-tRNA synthetase charges transfer RNA with its specific amino acid. Release factors bind stop codons to terminate translation and release completed polypeptides. Initiation factors assist ribosomal subunits in binding messenger RNA to start translation correctly.

43. (B) 60S and 40S
Eukaryotic cytoplasm contains 80S ribosomes composed of two distinct ribonucleoprotein subunits. The larger subunit sedimenting at 60S contains ribosomal proteins and multiple rRNA molecules, while the smaller subunit sedimenting at 40S contains a single rRNA species alongside proteins. Together, these subunits assemble upon messenger RNA templates during translation initiation to synthesize proteins.

44. (A) 50S and 30S
Prokaryotic organisms possess 70S ribosomes consisting of two unequal functional subunits. The large subunit sediments at 50S and houses peptidyl transferase catalytic activity, whereas the small subunit sediments at 30S and manages messenger RNA codon recognition. Their coordinated association creates functional translation complexes necessary for bacterial protein synthesis and cellular survival.

45. (C) Ribozyme
A ribozyme is an RNA molecule possessing enzymatic catalytic activity. Unlike traditional protein enzymes, ribozymes utilize structural RNA folds to catalyze specific biochemical reactions. In protein synthesis, the peptidyl transferase activity residing within the large ribosomal subunit is mediated directly by ribosomal RNA rather than ribosomal proteins, exemplifying ribozyme function in living cells.

46. (D) Polyribosome
A polyribosome, or polysome, consists of a complex formed when multiple individual ribosomes concurrently translate a single messenger RNA strand. Moving sequentially from the five-prime to three-prime end, each ribosome independently synthesizes a polypeptide chain, dramatically increasing the rate and efficiency of protein production from a single mRNA molecule within cells.

47. (A) It is a linear strand without loops
Transfer RNA is not a simple linear molecule lacking internal structural elements. In reality, tRNA strands undergo extensive internal complementary base pairing, folding into a characterized cloverleaf secondary structure featuring stem-loops. This complex folded shape

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88. (A) P-2, Q-1, R-4, S-3
Chromosomal complements define human biological identity across somatic and reproductive cells. Somatic female cells contain 44 autosomes plus XX, while male somatic cells contain 44 autosomes plus XY. Gametic cells carry haploid sets: ova or female-determining sperms contain 22 autosomes plus X, whereas male-determining sperms carry 22 autosomes plus Y.

89. (C) Male
Fertilization occurs when a male haploid sperm fuses with a female haploid ovum. If the fertilizing sperm carries a Y chromosome alongside 22 autosomes, it combines with the ovum carrying an X chromosome and 22 autosomes. This forms a diploid zygote with 44 autosomes and an XY sex complement, developing into a male.

90. (A) SRY gene
Male sexual differentiation is driven by the Sex-determining Region Y (SRY) gene located on the short arm of the Y chromosome. Encoding testis-determining factor protein, SRY expression during early embryonic development triggers undifferentiated bipotential gonads to develop into functional testes, directing male anatomical and physiological development.

91. (C) It is much smaller than the X chromosome
The human Y chromosome is significantly smaller in physical size and gene content compared to the X chromosome. Containing roughly 50 to 60 million base pairs, the Y chromosome carries few protein-coding genes, primarily related to male gonadal differentiation and spermatogenesis, whereas the much larger X chromosome contains over 800 genes governing diverse functions.

92. (B) The X chromosome contains fewer genes than Y.
Statement B is false because the human X chromosome is substantially larger and contains roughly 800 to 900 protein-coding genes, compared to the Y chromosome which contains significantly fewer genes. Statements A, C, and D accurately reflect established patterns of human karyology, sex chromosome distribution, and gamete production.

93. (C) 1:1
Normal meiotic division during male spermatogenesis segregates homologous X and Y sex chromosomes equally into haploid spermatids. Consequently, mature spermatozoa are produced in an exact one-to-one ratio, where fifty percent carry an X chromosome and fifty percent carry a Y chromosome, maintaining balanced primary sex ratios in human populations.

94. (D) Sex-linked genes
Genes located specifically on sex chromosomes that lack corresponding alleles on partner sex chromosomes are termed sex-linked genes. Because the X chromosome is substantially larger than the Y chromosome, most sex-linked traits are X-linked, exhibiting distinctive transmission patterns across generations due to hemizygosity in human males.

95. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Paternal sperm identity determines offspring sex in humans. Mothers are homogametic, producing ova carrying strictly X chromosomes, while fathers are heterogametic, producing X-bearing or Y-bearing sperms in equal ratios. Thus, the fertilizing paternal sperm dictates offspring sex, confirming that the reason fully explains the assertion.

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96. (B) Hemizygous
Males are hemizygous for X-linked genetic loci because they possess only a single X chromosome paired with a Y chromosome. Lacking a second X chromosome to carry potential counteracting dominant alleles, any mutant allele present on a male's X chromosome will be expressed in his phenotype, whether inherently recessive or dominant.

97. (B) Criss-cross inheritance
Criss-cross inheritance describes the transmission pattern characteristic of X-linked recessive traits. Affected fathers pass their mutant X chromosome to their daughters, who become phenotypically normal carriers. These carrier daughters subsequently transmit the mutant X chromosome to their sons, allowing traits to jump generations from maternal grandfathers to grandsons.

98. (A) X-linked recessive
Red-green colour blindness is an X-linked recessive congenital disorder caused by mutations in opsin genes located on the X chromosome. Because affected alleles are recessive, females require two

in managing mRNA stability, nuclear transport efficiency, and translation initiation rates within cells.

58. (A) P-4, Q-1, R-2, S-3
Functional regions within translation complexes handle distinct steps during protein synthesis. The A-site accepts incoming charged aminoacyl-tRNAs. The P-site holds the peptidyl-tRNA attached to the growing protein chain. The E-site provides an exit route for uncharged tRNAs. The mRNA binding site situated on the small ribosomal subunit aligns codons correctly during initiation.

59. (D) Presence of Mg^{2+} ions
Divalent magnesium ions are critical chemical factors necessary for maintaining structural integrity and association of ribosomal subunits. Adequate concentrations of Mg^{2+} ions neutralize negative charges on ribosomal RNA sugar-phosphate backbones, facilitating stable assembly of small and large subunits into active 70S or 80S ribosomes during translation initiation.

60. (B) II and III only
Statement one is incorrect because translation occurs in the cytoplasm or on rough endoplasmic reticulum membranes, whereas transcription occurs in eukaryotic nuclei. Statement two is correct as translation consumes significant energy via ATP and GTP hydrolysis. Statement three is also correct because peptidyl transferase ribozyme activity catalyzes peptide bond formation between adjacent amino acids.

61. (C) Proteins
Gene expression is the process by which genomic information encoded within DNA directs the synthesis of functional cellular products. While some genes encode structural or catalytic RNA molecules, the primary physiological manifestation of gene expression occurs through protein synthesis, yielding enzymes, structural components, and regulatory factors that dictate cellular phenotype and metabolism.

62. (D) Enzymes
Enzymes are biological catalysts composed primarily of globular proteins synthesized through gene expression pathways. By lowering activation energy barriers, enzymes accelerate specific biochemical reactions within cells by orders of magnitude without being consumed. Their continuous regulated synthesis ensures precise control over metabolic pathways necessary for cellular homeostasis, growth, and repair.

63. (A) Peptide hormone
Insulin is a essential metabolic regulator secreted by pancreatic beta cells to control systemic glucose levels. Chemically, insulin is a peptide hormone consisting of two amino acid chains linked by disulfide bonds. It is synthesized via standard gene transcription and translation pathways as preproinsulin before undergoing post-translational cleavage into functional insulin.

64. (B) Point mutation
A point mutation is a specific genetic alteration involving a change, insertion, or deletion of a single nucleotide base pair within a DNA sequence. Depending on location and nature, point mutations can alter single codons, leading to missense, nonsense, or silent effects during protein translation, potentially impacting overall polypeptide structure and biological activity.

65. (A) II, IV, I, III
Translation follows a mandatory structural sequence. First, messenger RNA binds to the small ribosomal subunit to initiate translation. Next, amino acids are joined as peptidyl transferase catalyzes peptide bond formation. Then, translocation moves the ribosome along mRNA to read subsequent codons. Finally, termination release factors liberate the completed functional polypeptide chain.

66. (A) Frameshift mutation
A frameshift mutation occurs when nucleotide insertions or deletions in numbers not divisible by three disrupt the contiguous triplet reading frame of messenger RNA. This shifts all downstream codons, altering the entire subsequent amino acid sequence during translation and frequently generating premature stop codons that produce severely truncated, non-functional proteins.

67. (C) Nonsense mutation
A nonsense mutation is a point mutation in genomic DNA that changes an amino acid-specifying codon into one of three stop codons (UAA, UAG, or UGA). During translation, this premature stop signal halts ribosome progress prematurely, yielding an incomplete polypeptide

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28. (B) P-3, Q-4, R-1, S-2
The genetic code exhibits several key characteristics. Degeneracy means multiple codons can code for one amino acid. Unambiguity indicates that one specific codon designates only one amino acid. Commaless structure means codons are read continuously without punctuation. Universality reflects that identical codon assignments operate across virtually all extant living organisms, preserving information transfer principles.

29. (C) Degeneracy
Degeneracy in the genetic code refers to the structural redundancy where multiple distinct triplet codons can encode the exact same amino acid. Because sixty-one sense codons specify only twenty standard amino acids, most amino acids are represented by more than one codon, providing structural tolerance against point mutations in genomic DNA sequences.

30. (D) UAC
Protein synthesis termination relies on three canonical stop codons: UAA, UAG, and UGA. These specific triplet sequences do not bind aminoacyl-tRNAs, signaling translation machinery to halt polypeptide elongation. Conversely, UAC is a sense codon that specifically encodes the amino acid tyrosine, rendering it functional in amino acid coding rather than translation termination signaling.

31. (A) Do not code for an amino acid
Stop codons are termed nonsense codons because they do not correspond to any transfer RNA molecule carrying an amino acid. When a ribosome encounters UAA, UAG, or UGA along a messenger RNA strand, no charged tRNA enters the aminoacyl site. Instead, release factors bind, triggering polypeptide chain release and ribosomal subunit dissociation.

32. (B) Marshall Nirenberg
Marshall Nirenberg made landmark contributions to molecular biology by deciphering the genetic code. Utilizing cell-free protein synthesis systems and synthetic poly-uracil RNA templates, he demonstrated that UUU specifically codes for phenylalanine. His pioneering experimental approaches ultimately allowed scientists to systematically map all sixty-four triplet codons to their respective amino acids during the 1960s.

33. (B) One codon codes for one amino acid
Unambiguity is a fundamental property of the genetic code guaranteeing high specificity during protein translation. It means that any particular triplet codon codes for strictly one specific amino acid under normal biological conditions. While an amino acid may have several codons due to degeneracy, no single codon ever specifies more than one unique amino acid.

34. (A) On the tRNA molecule
The anticodon is a specific three-nucleotide sequence situated on the specialized anticodon loop of a transfer RNA molecule. During ribosomal translation, these three bases form complementary base pairs with matching triplet codons present on messenger RNA, ensuring that correct amino acids attached to transfer RNA are inserted sequentially into growing polypeptide chains.

35. (A) II, III, I, IV
Gene expression proceeds through a defined chronological sequence of biological steps. First, genomic DNA undergoes transcription into primary RNA transcripts within the nucleus. Next, post-transcriptional processing removes non-coding introns via splicing. Subsequently, mature mRNA enters the cytoplasm and binds to ribosomes, where translation proceeds through continuous elongation of the polypeptide chain.

36. (D) Aminoacylation of tRNA
Aminoacylation, commonly termed tRNA charging, is the biochemical process that covalently attaches a specific amino acid to its cognate transfer RNA molecule. Catalyzed by aminoacyl-tRNA synthetase enzymes, this two-step reaction requires energy derived from adenosine triphosphate, creating a high-energy ester bond that subsequently fuels peptide bond formation during ribosomal translation.

37. (C) Base pairing between codon and anticodon
Accuracy during protein translation relies on precise physical interactions between messenger RNA and transfer RNA molecules. This interaction is driven by complementary hydrogen base pairing between the three-base codon on messenger RNA and the complementary three-base anticodon loop on transfer RNA, ensuring faithful translation of encoded genetic messages into correct amino acid sequences.

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physiological regulators uninvolved in primary sex determination pathways.

78. (D) Sex chromosomes
The 23rd pair of chromosomes in human cells consists of sex chromosomes, designated as X and Y. Unlike autosomal pairs governing non-sex biological traits, sex chromosomes carry specific regulatory genes that direct gonad differentiation, reproductive anatomy development, and secondary sexual character traits during embryonic growth and human development.

79. (A) XX
Biological sex determination in human females is characterized by an XX chromosomal complement. Somatic cells in normal females possess 22 pairs of autosomes alongside two morphologically identical X sex chromosomes. During meiosis, female germ cells produce gametes containing exclusively X chromosomes, reflecting homogametic sex inheritance patterns.

80. (B) I and III only
Statement one is correct because gene expression requires transcription of DNA to RNA and translation into proteins. Statement two is incorrect because gene expression is dynamically regulated based on cellular signaling and environmental needs, not continuously expressed. Statement three is correct as functional RNA or protein molecules represent ultimate products of expressed genes.

81. (B) XY
Normal human males feature an XY sex chromosome complement within their diploid karyotype. Somatic cells contain 22 pairs of autosomes combined with one X chromosome and one smaller Y chromosome. This heterogametic configuration results in males producing two distinct sperm types during spermatogenesis, driving sex determination upon fertilization.

82. (A) Nucleotide → Codon → Gene → Chromosome
Genetic material is organized in hierarchical levels of complexity. Nucleotides represent fundamental monomeric units. Three consecutive nucleotides form a codon specifying an amino acid. Multiple codons form functional genes encoding entire proteins. Finally, thousands of genes combine along extensive DNA molecules packaged with proteins to constitute individual chromosomes within nuclei.

83. (C) Heterogametic
Human males are designated as heterogametic because meiotic division during male spermatogenesis produces two distinct classes of haploid gametes in equal proportions. Fifty percent of sperms carry a single X chromosome, whereas the remaining fifty percent carry a single Y chromosome, establishing the genetic mechanism underlying offspring sex determination.

84. (D) Father
Biological sex in humans is determined entirely by male gametes supplied at fertilization. Because females produce eggs carrying exclusively X chromosomes, the sex of offspring depends on whether an X-bearing or Y-bearing sperm fertilizes the ovum. Consequently, paternal inheritance dictates whether zygotes develop female (XX) or male (XY) chromosomal complements.

85. (A) IV, II, I, III
Human reproduction follows a chronological sequence. Meiosis occurs within male testicular germ cells, producing distinct X-bearing and Y-bearing sperms. Subsequent fertilization occurs when a sperm unites with an ovum. This union restores diploidy, forming either an XX or XY zygote that develops into a female or male offspring.

86. (B) 50%
During human reproduction, male gametogenesis produces X-bearing and Y-bearing sperms in an exact one-to-one proportion. Because ova contain only X chromosomes, fertilization by either sperm type occurs with equal probability. Consequently, each individual pregnancy carries a theoretical fifty percent probability of yielding a female child or male child.

87. (D) Only X chromosome
Human females possess an XX sex chromosome constitution in diploid germ cells. When these cells undergo meiotic division during oogenesis, homologous X chromosomes segregate equally into haploid daughter cells. As a result, every functional ovum produced by a female universally carries 22 autosomes and a single X chromosome.

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which are covalently joined by peptide bonds to construct functional polypeptide chains essential for cellular structure and biochemical pathways.

10. (A) tRNA
Transfer RNA functions as a crucial adapter molecule during protein synthesis within cellular environments. Possessing a unique cloverleaf secondary fold, it features a specific anticodon loop capable of base-pairing with messenger RNA codons, alongside an amino acid attachment site. This dual specificity ensures accurate placement of individual amino acids into growing polypeptide chains during translation.

11. (D) Nucleus
In eukaryotic organisms, genetic material is compartmentalized within a membrane-bound nucleus separate from the cytoplasm. Consequently, DNA transcription into primary RNA transcripts occurs exclusively inside this nuclear envelope. Following synthesis and post-transcriptional processing, mature messenger RNA molecules exit through nuclear pore complexes into the cytoplasm, where ribosomal protein translation subsequently takes place.

12. (B) P-4, Q-2, R-1, S-3
Distinct RNA molecules carry out specialized functions during cellular gene expression pathways. Messenger RNA conveys genetic instructions transcribed from DNA templates. Transfer RNA transports specific amino acids to translation machinery. Ribosomal RNA provides structural frameworks and catalytic activity within ribosomes. Small nuclear RNA participates directly in splicing pre-messenger RNA molecules within eukaryotic nuclear environments.

13. (C) RNA Polymerase
RNA polymerase is the primary enzyme complex responsible for synthesizing RNA molecules from DNA templates during transcription. It binds to specific promoter sequences, unwinds the DNA double helix, and catalyzes phosphodiester bond formation between ribonucleotides. This enzymatic activity proceeds along the template strand, assembling a complementary single-stranded RNA molecule with high speed and precision.

14. (D) Promoter
A promoter is a specialized regulatory DNA sequence located upstream of a gene that signals the initiation site for transcription. It provides specific binding sites for RNA polymerase and associated transcription factors. Proper promoter recognition ensures that transcription begins at the precise nucleotide locus, establishing correct orientation and frame for functional RNA strand synthesis.

15. (A) Terminator
A terminator sequence is a specific region of genomic DNA that signals the completion of RNA synthesis during transcription. Upon encountering this regulatory sequence, the transcribing RNA polymerase complex undergoes structural changes, halts nucleotide polymerization, and releases both the newly synthesized primary RNA transcript and the DNA template strand, completing the transcription process.

16. (B) 5' to 3' direction
Nucleic acid polymerization by RNA polymerase follows strict chemical polarity rules during transcription. The enzyme adds incoming ribonucleoside triphosphates exclusively to the free three-prime hydroxyl group of the growing RNA chain. Consequently, RNA strands are synthesized in a continuous five-prime to three-prime direction, while reading the underlying template DNA strand in a three-prime to five-prime direction.

17. (B) Template strand
During transcription, only one of the two exposed DNA strands serves as a physical guide for RNA synthesis. This strand, oriented in the three-prime to five-prime direction, is known as the template strand. RNA polymerase reads its nucleotide sequence to construct a complementary single-stranded RNA transcript possessing identical sequence polarity to the non-template strand.

18. (A) Introns
Eukaryotic genes frequently contain intervening non-coding regions interspersed between protein-coding segments within primary RNA transcripts. These non-coding regions, termed introns, do not contribute to the final amino acid sequence of proteins. Consequently, introns must be precisely excised from precursor messenger

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mutant copies to express the condition, whereas hemizygous males express the phenotype with only one copy, making the disorder far more prevalent in males.

99. (C) Difficulty distinguishing red and green
Red-green colour blindness impairs the function of green-sensitive or red-sensitive cone photoreceptor cells within the retinal macula. Affected individuals retain general visual acuity but experience persistent difficulty distinguishing between red and green hues, seeing them as muted or similar shades depending on whether protan or deutan gene defects are present.

100. (A) I and II only
Statements I and II are correct because males receive their Y chromosome from fathers and females receive X chromosomes from both parents. Statement III is incorrect because paternal sperms, carrying either X or Y chromosomes, determine whether offspring develop as male or female, making the father responsible for sex determination.

101. (C) Males need only one mutant allele to express the disorder.
X-linked recessive conditions affect males disproportionately due to hemizygosity. Because human males possess only one X chromosome paired with a non-homologous Y chromosome, possessing a single mutant allele on their X chromosome guarantees disease expression, whereas females require two defective alleles across both X chromosomes to manifest traits.

102. (B) P-3, Q-1, R-2, S-4
Key sex-linked genetic concepts reflect specific physiological traits. Colour blindness results from defects in red-green cone cells. Haemophilia represents an X-linked recessive bleeding disorder. Carrier females possess one normal and one mutant X chromosome. Hemizygosity describes males possessing a single X chromosome lacking corresponding alleles on Y.

103. (C) All sons will have normal vision
Sons inherit their single X chromosome exclusively from their mother, while receiving a Y chromosome from their father. If a mother is non-carrier and possesses two normal vision X chromosomes, all her sons will inherit a normal X chromosome regardless of paternal vision, ensuring one hundred percent normal vision among male offspring.

104. (A) Failure of blood to clot properly
Haemophilia is a hereditary bleeding disorder caused by deficiencies in specific blood clotting factor proteins. Due to impaired coagulation cascades, affected individuals experience delayed blood clotting following injuries, alongside spontaneous internal hemorrhaging into joints and soft tissues, requiring clinical administration of missing clotting factors for management.

105. (C) Queen Victoria
Haemophilia gained historical prominence as the Royal Disease because Queen Victoria of the United Kingdom was a spontaneous carrier of the X-linked recessive allele for Haemophilia B. She passed the mutant gene to several royal descendants, spreading the disorder across royal families of Britain, Germany, Russia, and Spain.

106. (A) Factor VIII
Haemophilia A, the most common classical form of haemophilia, is caused by loss-of-function mutations in the F8 gene on the X chromosome. This gene encodes antihemophilic factor, or Factor VIII, a crucial blood-coagulation protein essential for stable fibrin clot formation during normal physiological blood clotting processes.

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107. (D) Carrier
A female possessing one normal allele and one mutated recessive allele for an X-linked trait is designated a genetic carrier. Supported by the dominant normal allele on her second X chromosome, she displays normal physiological function without disease symptoms, yet retains a fifty percent chance of transmitting the mutant allele to offspring.

108. (B) Sickle cell anemia
Sickle cell anemia is an autosomal recessive genetic disorder caused by point mutations in the HBB gene located on chromosome 11, rather than a sex-linked trait. Conversely, red-green colour blindness, haemophilia, and Duchenne muscular dystrophy represent classic sex-linked disorders caused by mutant genes located on the human X chromosome.

109. (C) 50%
A carrier woman for haemophilia possesses one normal X chromosome and one mutant X chromosome. Because male offspring inherit their

(D) The complete evolutionary history and lineage of the organism

24. No two different species can occupy the exact same ecological niche in the same habitat indefinitely. This concept is known as?
(A) Allen's Rule
(B) Bergmann's Rule
(C) Competitive Exclusion Principle
(D) Principle of Tolerance

25. The transition zone between two or more diverse ecosystems (e.g., between a forest and a grassland) is known as?
(A) Ecotype
(B) Ecocline
(C) Niche
(D) Ecotone

26. The tendency for increased population density and biodiversity at the boundary area between two ecosystems is called?
(A) Edge effect
(B) Greenhouse effect
(C) Allee effect
(D) Bottleneck effect

27. Identify the incorrect statement among the following.
(A) A habitat can be shared by multiple species.
(B) All species in a community have identical ecological niches.
(C) A niche encompasses an organism's diet, activity patterns, and interactions.
(D) Microhabitat is a small, specific area within a larger habitat.

28. Match the biotic components in List I with their appropriate examples in List II.
List I: (Biotic Components)
P. Producer
Q. Primary Consumer
R. Secondary Consumer
S. Decomposer
List II: (Examples)
1. Grasshopper
2. Fungus
3. Mango Tree
4. Frog
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

29. The term flora refers to the?
(A) Plant life of a particular region
(B) Animal life of a particular region
(C) Microorganisms found in the soil
(D) Dissolved minerals in a water body

30. Which of the following is NOT an attribute of a population?
(A) Birth rate
(B) Death rate
(C) Stratification
(D) Sex ratio

31. A grazing food chain always begins with?
(A) Herbivores
(B) Dead decaying matter
(C) Top carnivores
(D) Primary producers

32. Which of the following represents the correct sequence of a terrestrial grazing food chain?
(A) Grass → Frog → Grasshopper → Snake → Eagle
(B) Grasshopper → Grass → Snake → Frog → Eagle
(C) Grass → Grasshopper → Frog → Snake → Eagle
(D) Eagle → Snake → Frog → Grasshopper → Grass

33. The detritus food chain originates from?
(A) Sunlight
(B) Dead organic matter
(C) Green plants
(D) Primary consumers

34. According to the 10% law of energy transfer in a food chain, approximately what percentage of energy is passed from one trophic level to the next?
(A) 1%
(B) 10%
(C) 50%
(D) 90%

35. The 10% law of energy flow in an ecosystem was proposed by?
(A) Raymond Lindeman
(B) Charles Darwin
(C) Ernst Haeckel
(D) Norman Myers

36. An interconnected and complex network of multiple food chains in an ecosystem is termed as a?
(A) Ecological pyramid

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clinically healthy heterozygous carriers of the haemophilia gene.

120. (A) Protein synthesis
Molecular genetics reveals that inherited disorders like haemophilia stem from DNA mutations that disrupt normal protein synthesis. Mutations alter mRNA coding sequences, yielding missing or non-functional clotting factor proteins like Factor VIII. This demonstrates how molecular errors in central dogma pathways directly produce pathological conditions in humans.

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(C) Species level only
(D) Ecosystem level only

72. Which prominent socio-biologist popularized the term 'Biodiversity'?
(A) Norman Myers
(B) Rachel Carson
(C) Edward O. Wilson
(D) Paul Ehrlich

73. Which of the following regions in India is recognized as a major biodiversity hotspot?
(A) Thar Desert
(B) Deccan Plateau
(C) Gangetic Plains
(D) Western Ghats

74. Given below are two statements, one labeled as Assertion (A) and the other as Reason (R).
Assertion (A): The Great Indian Bustard (Godawan) is classified as a critically endangered species.
Reason (R): Its natural habitat in the arid regions of Rajasthan and Gujarat is rapidly shrinking due to human intervention and infrastructure development.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

75. Species that are confined to a single specific geographical region and are not found anywhere else in the world are known as?
(A) Exotic species
(B) Endemic species
(C) Extinct species
(D) Pandemic species

76. The 'Red Data Book', which maintains a public record of endangered and threatened species, is published by?
(A) WHO
(B) IUCN
(C) WWF
(D) UNEP

77. A 'Biodiversity Hotspot' is specifically characterized by?
(A) High species richness, high endemism, and severe habitat threat
(B) Regions characterized by extremely low temperatures and sparse vegetation
(C) Ecosystems dominated exclusively by introduced exotic non-native species
(D) Pristine areas with a complete absence of human intervention in history

78. Match the conservation strategies in List I with their corresponding examples in List II.
List I: (Conservation Strategies)
P. In-situ conservation (Terrestrial)
Q. In-situ conservation (Aquatic)
R. Ex-situ conservation (Plants)
S. Ex-situ conservation (Animals)
List II: (Examples)
1. Zoological Park
2. Marine Protected Area
3. Botanical Garden
4. National Park
(A) P-4, Q-2, R-3, S-1
(B) P-1, Q-3, R-2, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-3, S-1

79. In Rajasthan, community-protected forest patches dedicated to local deities, which play a major role in regional biodiversity conservation, are known as?
(A) Mangroves
(B) Jhum
(C) Taiga
(D) Orans

80. The primary cause of species extinction in recent times is?
(A) Gradual natural climate change occurring over several millennia
(B) Catastrophic global volcanic eruptions and atmospheric ash
(C) Human-driven habitat destruction and loss
(D) Long-term increases in solar radiation reaching the surface

81. Which of the following is a completely extinct species?
(A) Asian Elephant
(B) Dodo
(C) Snow Leopard
(D) Great Indian Bustard

82. Keoladeo Ghana National Park, located in Rajasthan, is world-famous as a wintering ground for which migratory bird?
(A) Arctic Tern
(B) Greater Flamingo
(C) Pelican

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(B) To convert solar energy into chemical energy via photosynthesis
(C) To live as specialized parasites on other living plant tissues
(D) To break down complex organic compounds into simple nutrients

13. Animals that feed directly on green plants are categorized as?
(A) Primary consumers
(B) Secondary consumers
(C) Tertiary consumers
(D) Decomposers

14. Which of the following best describes secondary consumers?
(A) They produce organic food independently through photosynthesis.
(B) They break down dead plant materials and decaying detritus.
(C) They feed on primary consumers and act as carnivores.
(D) They feed exclusively on seeds, fruits, and plant tissues.

15. Match the ecological terms in List I with the scientists associated with them in List II.
List I: (Ecological Terms)
P. Ecology
Q. Ecosystem
R. Biodiversity
S. Ecological Niche
List II: (Scientists)
1. A.G. Tansley
2. W.G. Rosen
3. Ernst Haeckel
4. Joseph Grinnell
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-3, S-2

16. Fungi and bacteria that feed on dead and decaying organic matter are called?
(A) Autotrophs
(B) Predators
(C) Decomposers
(D) Scavengers

17. Edaphic factors in an ecosystem refer to parameters associated with?
(A) Light
(B) Soil
(C) Wind
(D) Water

18. The major primary producers in an open ocean ecosystem are?
(A) Seaweeds
(B) Zooplankton
(C) Mangroves
(D) Phytoplankton

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19. Given below are two statements, one labeled as Assertion (A) and the other as Reason (R).
Assertion (A): The flow of energy in an ecosystem is always unidirectional.
Reason (R): Energy dissipated as heat to the environment cannot be reused by plants for photosynthesis.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

20. Which of the following is the odd one out with respect to trophic levels?
(A) Grass
(B) Cyanobacteria
(C) Earthworm
(D) Algae

21. A group of individuals of the same species living in a specific geographical area at a given time is called a?
(A) Population
(B) Biome
(C) Community
(D) Ecosystem

22. The assemblage of interacting populations of different species living in a particular area constitutes a?
(A) A genetically identical group or clone
(B) A specific physical habitat zone
(C) The entire global biosphere
(D) A localized biotic community

23. While a habitat is the specific physical place where an organism lives, an ecological niche represents?
(A) The external physical appearance and morphology of the organism
(B) The functional role of the organism in its environment
(C) The maximum potential lifespan and longevity of the organism

CHAPTER 13
Environment and Ecosystem Structure

1. The term ecology was first coined and properly defined by which of the following scientists?
(A) A.G. Tansley
(B) Ernst Haeckel
(C) Charles Elton
(D) Joseph Grinnell

2. Which of the following best defines the term environment?
(A) Only the physical conditions surrounding an organism
(B) Only the biological living communities in a given area
(C) The natural habitat of endangered species only
(D) The sum total of all biotic and abiotic factors that surround and influence an organism

3. Who among the following is recognized as the Father of Ecology in India?
(A) Ramdeo Misra
(B) M.S. Swaminathan
(C) Salim Ali
(D) Madhav Gadgil

4. The structural and functional unit of nature where living organisms interact among themselves and with the physical environment is known as?
(A) Population
(B) Biome
(C) Ecosystem
(D) Biosphere

5. The term ecosystem was introduced in 1935 by?
(A) A.G. Tansley
(B) E.P. Odum
(C) Carl Möbius
(D) Karl Möbius

6. The study of the ecological relations of a single species or a single population in its environment is called?
(A) Synecology
(B) Deep ecology
(C) Applied ecology
(D) Autecology

7. Which of the following is an abiotic component of an ecosystem?
(A) Soil fungi
(B) Temperature
(C) Earthworms
(D) Phytoplankton

8. Consider the following statements regarding the characteristics of an ecosystem:
I. It is an open system with continuous input of energy and output of waste.
II. It has both structural and functional components.
III. It is a completely static entity with no temporal changes.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

9. The narrow zone where the lithosphere, hydrosphere, and atmosphere interact to support life is known as the?
(A) Stratosphere
(B) Troposphere
(C) Mesosphere
(D) Biosphere

10. The biological community along with the physical environment with which it interacts is called?
(A) Ecosystem
(B) Habitat
(C) Niche
(D) Ecotone

11. Which of the following organisms are classified as primary producers in a terrestrial ecosystem?
(A) Herbivores
(B) Green plants
(C) Saprophytes
(D) Primary carnivores

12. What is the primary role of autotrophs in an ecosystem?
(A) To consume dead organic matter and break down decaying tissues

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(B) Trophic level
(C) Food web
(D) Biomass network

37. Which of the following statements best describes the advantage of a food web over a simple food chain?
(A) It enhances ecosystem stability via alternate food paths.
(B) It drastically reduces the overall biodiversity of the ecosystem.
(C) It channels all available energy exclusively to a single top predator.
(D) It strictly limits the natural recycling and flow of nutrients in soil.

38. Given below are two statements, one labeled as Assertion (A) and the other as Reason (R).
Assertion (A): Decomposers do not occupy a specific single position in a typical grazing food chain diagram.
Reason (R): Decomposers act across all trophic levels by breaking down the dead remnants of producers, herbivores, and carnivores.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

39. The process by which the concentration of certain toxic non-biodegradable chemicals increases at each successive trophic level is known as?
(A) Eutrophication
(B) Biomagnification
(C) Bioremediation
(D) Carbon sequestration

40. In an ecosystem heavily polluted with DDT, the highest concentration of the chemical is typically found in?
(A) Water
(B) Phytoplankton
(C) Fish-eating birds
(D) Small fishes

41. The graphical representation of the trophic structure and function of an ecosystem is called an ecological pyramid. This concept was developed by?
(A) E.P. Odum
(B) A.G. Tansley
(C) G.F. Gause
(D) Charles Elton

42. Arrange the following trophic levels of a grazing food chain in the correct bottom-to-top sequence (from base of the pyramid to the apex).
1. Tertiary Consumer
2. Primary Consumer
3. Producer
4. Secondary Consumer

(A) 3, 2, 4, 1
(B) 1, 4, 2, 3
(C) 3, 4, 2, 1
(D) 2, 3, 1, 4

43. Which of the following ecological pyramids is always upright and can never be inverted?
(A) Pyramid of Numbers
(B) Pyramid of Energy
(C) Pyramid of Biomass
(D) Pyramid of Species

44. The pyramid of numbers in a single large tree ecosystem (where the tree supports many insects, which support birds) is typically?
(A) Upright
(B) Inverted
(C) Spindle-shaped
(D) Horizontal

45. Match the type of ecological pyramid in List I with the corresponding ecosystem example in List II.
List I: (Type of Ecological Pyramid)
P. Upright Pyramid of Numbers
Q. Inverted Pyramid of Numbers
R. Upright Pyramid of Biomass
S. Inverted Pyramid of Biomass
List II: (Ecosystem Example)
1. Aquatic Ecosystem (Pond)
2. Forest Ecosystem
3. Grassland Ecosystem
4. Single Tree Ecosystem

(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-3, S-1

46. The total amount of living organic matter present at a particular trophic level at a given time is called?
(A) Standing state
(B) Gross primary productivity
(C) Standing crop
(D) Net primary productivity

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47. In a marine ecosystem, the pyramid of biomass is generally inverted because?
(A) The dominant top predators in aquatic systems are extremely small in size.
(B) Individual phytoplankton organisms possess a very long natural lifespan.
(C) Energy transfer efficiency between aquatic trophic levels reaches 100%.
(D) Phytoplankton biomass is less than consumer biomass.

48. What is a major limitation of ecological pyramids?
(A) They are exclusively designed to represent aquatic ecosystems.
(B) They assign disproportionately high ecological importance to decomposers.
(C) They ignore food webs and assume simple linear food chains.
(D) They strictly measure abiotic factors while completely ignoring biotic ones.

49. The SI unit generally used to express energy in an ecological pyramid of energy is?
(A) Kilograms per square meter (kg/m^2)
(B) Joules per square meter per year ($J/m^2/yr$)
(C) Grams per cubic centimeter (g/cm^3)
(D) Parts per million (ppm)

50. Which group of organisms is completely excluded from the typical ecological pyramids despite playing a critical role in ecosystems?
(A) Herbivores
(B) Top carnivores
(C) Producers
(D) Saprophytes / Decomposers

51. The Thar desert is characterized by high temperatures and low rainfall. Which of the following is a common adaptation found in the plants (xerophytes) of this ecosystem?
(A) Sunken stomata and thick cuticles
(B) Broad and thin leaves
(C) Shallow, poorly developed roots
(D) Presence of air bladders in stems

52. Which of the following is an example of a lentic (standing water) aquatic ecosystem?
(A) A fast-flowing river
(B) A natural spring
(C) A freshwater lake
(D) A mountain stream

53. The highly productive transition zone where a freshwater river meets the salty ocean water is called an?
(A) Estuary
(B) Atoll
(C) Upwelling zone
(D) Epipelagic zone

54. The taiga biome is mostly dominated by which type of vegetation?
(A) Broad-leaved deciduous trees
(B) Dense grasses and shrubs
(C) Cacti and succulents
(D) Coniferous evergreen trees

55. Consider the following adaptations in animals of the desert ecosystem of Rajasthan:
I. Nocturnal behavior to avoid daytime heat
II. Concentrated urine to conserve water
III. Sweating profusely to cool down the body
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

56. Which tree is deeply associated with the culture of Rajasthan and is considered a keystone species of the Thar desert ecosystem?
(A) Teak (Tectona grandis)
(B) Sal (Shorea robusta)
(C) Khejri (Prosopis cineraria)
(D) Banyan (Ficus benghalensis)

57. Which aquatic ecosystem is famous for having the highest primary productivity and is often called the "rainforest of the sea"?
(A) Deep ocean trenches
(B) Fast-flowing rivers
(C) Oligotrophic lakes
(D) Coral reefs

58. The process of vertical distribution of different species occupying different levels in an ecosystem (e.g., trees, shrubs, and herbs in a forest) is known as?
(A) Stratification
(B) Succession
(C) Eutrophication
(D) Ecotone

59. Which of the following best identifies the state animal of Rajasthan (wildlife category) that is highly adapted to the desert ecosystem?
(A) Asiatic Lion

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(B) Chinkara
(C) Blackbuck
(D) Snow Leopard

60. Identify the incorrect pair regarding types of ecosystems.
(A) Marine Ecosystem - Coral Reef
(B) Lotic Ecosystem - Pond
(C) Terrestrial Ecosystem - Grassland
(D) Artificial Ecosystem - Aquarium

61. The ability of an ecosystem to maintain a stable, balanced state despite minor environmental changes is referred to as?
(A) Homeostasis
(B) Ecological succession
(C) Biomagnification
(D) Stratification

62. Match the types of ecosystems in List I with their appropriate examples in List II.
List I: (Types of Ecosystems)
P. Natural Terrestrial
Q. Natural Lentic Aquatic
R. Natural Lotic Aquatic
S. Man-made / Artificial
List II: (Examples)
1. Crop field
2. River
3. Forest
4. Swamp/Lake
(A) P-3, Q-4, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-2, R-4, S-1

63. The gradual and predictable change in the species composition of a given area over time is called?
(A) Edge effect
(B) Carrying capacity
(C) Speciation
(D) Ecological succession

64. The first species to colonize a previously barren area (such as a bare rock) in primary succession are called?
(A) Climax species
(B) Serel communities
(C) Pioneer species
(D) Keystone species

65. Which of the following is the correct sequence of vertical stratification in a mature forest ecosystem, from the ground level upwards?
(A) Canopy trees → Understory trees → Shrubs → Ground cover
(B) Ground cover → Shrubs → Understory trees → Canopy trees
(C) Shrubs → Ground cover → Canopy trees → Understory trees
(D) Ground cover → Understory trees → Shrubs → Canopy trees

66. The final, stable community in an ecological succession that is in near equilibrium with the environment is called the?
(A) Pioneer community
(B) Transition community
(C) Seral stage
(D) Climax community

67. Which of the following is an example of secondary succession?
(A) Forest recovery following a severe wildfire
(B) Primary growth of pioneer lichens on newly cooled volcanic lava
(C) Initial biological colonization of a newly formed oceanic island
(D) First establishment of living organisms on a bare rock substrate

68. The maximum population size of a biological species that a specific environment can sustainably support is termed its?
(A) Biotic potential
(B) Ecological niche
(C) Carrying capacity
(D) Survivorship limit

69. A major consequence of large-scale deforestation is?
(A) Increased soil erosion and loss of biodiversity
(B) Increase in soil moisture retention
(C) Decrease in atmospheric carbon dioxide levels
(D) Expansion of groundwater reserves

70. "Jhum" cultivation, which has historically caused forest degradation in parts of India, is also known as?
(A) Stepwise mountain terrace farming
(B) Soil-less aquatic hydroponics
(C) Integrated forestry agroforestry
(D) Slash-and-burn farming

71. The term 'Biodiversity' encompasses variation at which of the following levels?
(A) Genetic level only
(B) Genetic, Species, and Ecosystem levels

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single X chromosome from their mother, each son has a fifty percent probability of inheriting the mutant X chromosome and expressing haemophilia, and a fifty percent probability of inheriting the normal allele.

110. (D) Cone cells
Colour vision in humans relies on specialized retinal photoreceptors called cone cells, which absorb distinct light wavelengths using photopigments. Red-green colour blindness arises from genetic defects affecting opsin protein synthesis within these cone cells, preventing accurate differentiation between red and green light frequencies while rod-mediated night vision remains normal.

111. (A) Pre-Conception and Pre-Natal Diagnostic Techniques Act
The PCPNDT Act stands for the Pre-Conception and Pre-Natal Diagnostic Techniques Act, enacted by the Parliament of India in 1994. This legal statute prohibits sex selection before or after conception and regulates prenatal diagnostic procedures to prevent misuse of technology for female foeticide and address declining child sex ratios.

112. (B) Disclosure of fetal sex to parents
The PCPNDT Act strictly prohibits medical personnel and ultrasound clinics from determining or disclosing the sex of a fetus to parents or relatives. While diagnostic ultrasonography remains legal for monitoring fetal development, revealing fetal sex is punishable under Indian law to prevent targeted female foeticide and maintain demographic balance.

113. (B) Pre-natal sex determination
Amniocentesis is a clinical procedure designed to analyze fetal cells in amniotic fluid to detect chromosomal abnormalities or metabolic disorders. However, because fetal sex can be determined by analyzing sex chromosomes in harvested cells, the technique has been illegally misused for female sex selection, prompting strict legal regulations under Indian statutes.

114. (A) The number of females per 1000 males in a population
In Indian demographic metrics, the term Sex Ratio is officially defined as the total number of females per 1,000 males within a specified population. This statistical index serves as a primary indicator of gender equality, societal health, female survival rates, and maternal mortality across distinct geographical regions and time periods.

115. (B) 928
According to official demographic data from the 2011 Census of India, the general sex ratio of Rajasthan was recorded at 928 females per 1,000 males. While reflecting improvement compared to previous census figures, this ratio remains lower than the national average, underscoring ongoing governmental initiatives promoting female child welfare.

116. (D) Rise in gender violence and trafficking
A severe deficiency of females relative to males distorts population structures, creating social imbalances. Severe gender skewing leads to marriage squeezes, increased social instability, elevated rates of gender-based violence, forced marriages, and human trafficking of women across regions, undermining social cohesion and gender safety within affected societies.

117. (C) Eradicate female foeticide and promote equality
Public awareness campaigns regarding sex determination aim to eliminate societal preference for male children and eradicate female foeticide practices. By promoting equal value, educational access, and legal rights for female children, these initiatives seek to normalize balanced child sex ratios, combat gender discrimination, and foster equitable socio-economic development.

118. (B) P-3, Q-4, R-2, S-1
Legal and demographic concepts highlight female protection issues. The PCPNDT Act regulates diagnostic techniques to prevent sex selection. Sex Ratio quantifies females per 1,000 males. Female foeticide describes illegal selective termination of female fetuses. Amniocentesis is a medical diagnostic procedure often illegally misused for prenatal sex determination.

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119. (D) Carriers of haemophilia
A father with haemophilia passes his single mutant X chromosome to all his daughters. Because the non-carrier mother supplies a normal X chromosome, all daughters inherit one normal allele and one mutant allele. Consequently, one hundred percent of their daughters will be

(D) Siberian Crane

83. Ranthambore National Park in Rajasthan is primarily renowned worldwide for the conservation of which apex predator?
(A) Bengal Tiger
(B) Asiatic Lion
(C) Indian Leopard
(D) Cheetah

84. Desert National Park, known for the conservation of the state bird Godawan, is spread across which two districts of Rajasthan?
(A) Jodhpur and Bikaner
(B) Nagaur and Churu
(C) Jaisalmer and Barmer
(D) Sriganganagar and Hanumangarh

85. Which of the following protected areas in Rajasthan is NOT designated as a Tiger Reserve?
(A) Sita Mata
(B) Sariska
(C) Mukundra Hills
(D) Ramgarh Vishdhari

86. Tal Chhapar Wildlife Sanctuary in Churu district is most famous for the conservation of?
(A) Wild Boar
(B) Sloth Bear
(C) Indian Wolf
(D) Blackbuck

87. Under the Wildlife Protection Act, in which specific zone of a Biosphere Reserve is absolutely no human activity or exploitation permitted?
(A) Buffer zone
(B) Core zone
(C) Transition zone
(D) Utility zone

88. Consider the following statements regarding protected areas in Rajasthan:
I. Sariska is a recognized Tiger Reserve.
II. Keoladeo National Park is recognized as a Ramsar Wetland Site.
III. Desert National Park is famous for a large population of wild Asiatic Lions.
Which of the above statement(s) is/are correct?
(A) I only
(B) I and II only
(C) II and III only
(D) I, II, and III

89. Project Tiger, a major wildlife conservation initiative in India, was launched in the year?
(A) 1972
(B) 1973
(C) 1980
(D) 1986

90. The fundamental difference between a Wildlife Sanctuary and a National Park in India is that?
(A) Sanctuaries permit limited human activities, whereas National Parks prohibit all private rights.
(B) Sanctuaries are exclusively established for plant conservation, whereas National Parks focus solely on animals.
(C) National Parks are privately owned and managed, whereas Sanctuaries are entirely state-owned public reserves.
(D) There is no functional or legal difference between them; both terms are legally and ecologically synonymous.

91. Which of the following is considered a primary air pollutant?
(A) Ozone
(B) Carbon monoxide
(C) Peroxyacetyl nitrate (PAN)
(D) Photochemical smog

92. Match the environmental pollutants in List I with the specific health diseases they cause in List II.
List I: (Environmental Pollutants)
P. Mercury
Q. Cadmium
R. Nitrate in drinking water
S. Fluoride in water
List II: (Health Diseases)
1. Minamata disease
2. Itai-Itai disease
3. Blue-baby syndrome (Methemoglobinemia)
4. Fluorosis (bone/tooth decay)
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-1, Q-3, R-2, S-4
(D) P-3, Q-4, R-1, S-2

93. Acid rain is primarily caused by the atmospheric emissions of which of the following gases?
(A) Sulphur dioxide and Nitrogen oxides
(B) Carbon dioxide and Methane
(C) Chlorofluorocarbons (CFCs)
(D) Ozone and Argon

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that feed upon them, despite high annual photosynthetic productivity.

48. (C) They ignore food webs and assume simple linear food chains.
A major limitation of ecological pyramids is their reliance on simplified, linear food chains, ignoring complex real-world food webs. They fail to accommodate species that operate at multiple trophic levels simultaneously, such as omnivores. Furthermore, ecological pyramids completely exclude saprophytes and decomposers, despite their critical contribution to ecosystem nutrient cycling and energy balance.

49. (B) Joules per square meter per year ($J/m^2/yr$)
The standard international unit used to quantify energy transfer rates in an ecological pyramid of energy is Joules per square meter per year, or kilocalories per square meter per year. This rate-based expression measures the continuous energetic productivity synthesized per unit area over time, accommodating seasonal efficiency variations across successive trophic levels.

50. (D) Saprophytes / Decomposers
Saprophytes and decomposers, such as fungi and heterotrophic soil bacteria, are systematically excluded from standard ecological pyramid diagrams. Despite playing an essential functional role by recycling dead organic matter and nutrients across all trophic levels, ecological pyramids only accommodate organisms operating within strictly linear grazing producer-consumer food chain structures.

51. (A) Sunken stomata and thick cuticles
Xerophytic plants adapted to hot, dry desert ecosystems like the Thar possess specialized structural adaptations to minimize transpiration water loss. Features such as sunken stomata, thick waxy cuticles on leaves, reduced leaf surface areas transformed into spines, and deep root systems allow these xerophytes to store moisture and survive extreme arid environments efficiently.

52. (C) A freshwater lake
Lentic aquatic ecosystems consist of standing or still freshwater bodies where water motion is minimal, such as lakes, ponds, swamps, and marshes. In contrast, lotic ecosystems involve fast-moving or flowing waters, including rivers, streams, and natural mountain springs. Freshwater lakes support distinct zonation patterns characterized by littoral, limnetic, and deep benthic regions.

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53. (A) Estuary
An estuary is a dynamic coastal transition zone where freshwater rivers merge with saline ocean water. Influenced by tidal fluctuations, estuaries exhibit brackish conditions with variable salinity levels. These areas accumulate abundant terrigenous and marine nutrients, rendering them highly productive aquatic ecosystems that function as vital breeding grounds and habitats for aquatic species.

54. (D) Coniferous evergreen trees
The taiga, or boreal forest biome, is characterized by cold subarctic climates dominated by needle-leaved coniferous evergreen trees such as pine, spruce, fir, and larch. These trees possess waxy needles and flexible conical branches adapted to withstand heavy snowfall and brief growing seasons, forming dense forest belts across high northern latitudes globally.

55. (A) I and II only
Desert animals in arid ecosystems exhibit specialized physiological and behavioral adaptations to conserve water and endure extreme heat. Many species display nocturnal habits, remaining underground during scorching daytime hours to limit evaporative loss. Additionally, they produce highly concentrated urine to retain body fluids. Profuse sweating would deplete vital moisture rapidly, making it non-adaptive.

56. (C) Khejri (Prosopis cineraria)
Khejri is a deep-rooted, drought-resistant tree deeply rooted in Rajasthan's cultural heritage and ecology. Recognized as a keystone species of the Thar desert ecosystem, it enriches soil fertility through nitrogen fixation, provides essential fodder, firewood, and shade, and sustains local wildlife and rural agricultural communities during harsh drought conditions across dry regions.

57. (D) Coral reefs
Coral reefs are marine ecosystems built by calcium carbonate structures secreted by coral polyps in warm shallow ocean waters. Often called the rainforests of the sea, coral reefs support extraordinary biodiversity and exhibit

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(D) Prevention and control of oceanic marine oil spill disasters

105. Match the following Wildlife Sanctuaries of Rajasthan in List I with their respective districts in List II.

List I: (Wildlife Sanctuaries)

P. Sita Mata Wildlife Sanctuary
Q. Tal Chhapar Sanctuary
R. Mount Abu Sanctuary
S. Ramgarh Vishdhari Sanctuary

List II: (Districts)

1. Pratapgarh
2. Churu
3. Sirohi
4. Bundi

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-3, R-2, S-4

106. The concept of 'Sustainable Development' was prominently defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" in 1987 by the?
(A) Brundtland Commission (Our Common Future)
(B) Intergovernmental Panel on Climate Change (IPCC)
(C) Kyoto Protocol Committee
(D) United Nations Environment Programme (UNEP)

107. Which of the following best describes 'Bioremediation'?
(A) Deploying heavy industrial machinery to dredge solid waste from polluted rivers
(B) Using biological organisms to clean up polluted environments
(C) Storing hazardous toxic chemical waste in deep subterranean rock formations
(D) Thermally incinerating high-risk biomedical waste at elevated temperatures

108. Amrita Devi Bishnoi is a legendary figure in the history of environmental protection in Rajasthan. She sacrificed her life to protect which trees?
(A) Banyan trees
(B) Khejri trees
(C) Neem trees
(D) Peepal trees

109. Which famous environmental movement took place in the Garhwal Himalayas where local communities hugged trees to prevent them from being cut down?
(A) Chipko Movement
(B) Narmada Bachao Andolan
(C) Appiko Movement
(D) Silent Valley Movement

110. Arrange the following solid waste management strategies in the accepted hierarchy from most preferred (best environmental outcome) to least preferred.

1. Recycle
2. Reduce
3. Dispose to landfill
4. Reuse

(A) 2, 4, 1, 3
(B) 1, 2, 4, 3
(C) 4, 2, 1, 3
(D) 2, 1, 4, 3

111. The process of capturing and storing atmospheric carbon dioxide over long periods to mitigate global warming is known as?
(A) Carbon dating
(B) Carbon footprinting
(C) Carbon oxidation
(D) Carbon sequestration

112. Ecosystem services are classified into different categories. Which of the following is an example of a "Provisioning Service" provided by ecosystems?
(A) Natural regulation of global climate patterns
(B) Essential nutrient cycling and topsoil formation
(C) Supply of food, timber, and fresh water
(D) Cultural, recreational, and spiritual benefits

113. Pollination of crops by bees and other insects is categorized under which type of ecosystem service?
(A) Provisioning service
(B) Regulating service
(C) Cultural service
(D) Aesthetic service

114. The Environment (Protection) Act, an umbrella legislation for environmental protection in India, was enacted by the Parliament in the year?
(A) 1972
(B) 1981
(C) 1986

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(D) 2002

115. Match the important Environmental Acts of India in List I with their respective years of enactment in List II.

List I: (Environmental Acts)

P. Wildlife (Protection) Act
Q. Water (Prevention and Control of Pollution) Act
R. Forest (Conservation) Act
S. Air (Prevention and Control of Pollution) Act

List II: (Years of Enactment)

1. 1972
2. 1974
3. 1980
4. 1981

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-1, Q-4, R-2, S-3
(D) P-4, Q-2, R-1, S-3

116. The Ramsar Convention is an intergovernmental treaty primarily focused on the conservation and wise use of?
(A) Mountain ecosystems
(B) Desert biomes
(C) Wetlands
(D) Tropical rainforests

117. Which of the following is a recognized Ramsar Wetland Site located in Rajasthan?
(A) Sambhar Salt Lake
(B) Pushkar Lake
(C) Nakki Lake
(D) Pichola Lake

118. Consider the following measures related to environmental protection:

I. Promoting the use of unleaded petrol in vehicles.
II. Installing electrostatic precipitators in thermal power plants.
III. Discharging untreated industrial effluents directly into rivers.

Which of the above statement(s) is/are correct regarding measures that help in reducing pollution?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

119. The thickness of the ozone layer in a column of air from the ground to the top of the atmosphere is measured in terms of?
(A) Decibels (dB)
(B) Dobson Units (DU)
(C) Parts per million (ppm)
(D) Becquerels (Bq)

120. The National Green Tribunal (NGT) was established in India primarily for?
(A) Direct administration and day-to-day management of national parks
(B) Conducting scientific agricultural research and sustainable farming trials
(C) Expeditious disposal of environmental protection cases
(D) Providing direct government financial loans to eco-friendly green industries

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ANSWERS

1. (B) Ernst Haeckel
German zoologist Ernst Haeckel coined and defined the term ecology in 1866 to describe the scientific study of interactions between organisms and their environment. Ecology originates from the Greek words oikos, meaning household, and logos, meaning study. Haeckel emphasized how physical conditions and biological relationships shape the living world across diverse natural ecosystems.

2. (D) The sum total of all biotic and abiotic factors that surround and influence an organism
Environment encompasses all surrounding conditions that influence the life, development, and survival of an organism. It integrates both living biotic components, such as plants, animals, and microorganisms, and non-living abiotic factors, including sunlight, temperature, water, air, and soil. These interconnected components constantly interact, forming a complex system that supports dynamic biological processes across the entire biosphere.

3. (A) Ramdeo Misra
Ramdeo Misra is recognized as the Father of Ecology in India due to his foundational contributions to ecological education and research. He established advanced ecology courses at Banaras Hindu University during the 1950s. His work on tropical plant communities, environmental dynamics, and conservation biology established ecological research frameworks that shaped environmental science programs throughout the nation.

4. (C) Ecosystem
An ecosystem represents the fundamental structural and functional unit of nature where living organisms interact among themselves and with non-living physical factors. Energy flows through trophic levels while mineral nutrients recycle within the system. Ecosystems vary in scale from small ponds to vast forests, maintaining ecological balance through dynamic interactions between biological communities and their physical environment.

5. (A) A.G. Tansley
British ecologist Arthur George Tansley introduced the term ecosystem in 1935 to describe the integrated system of biotic components and physical environmental factors. He emphasized that living organisms cannot be separated from their habitat, as both form an interactive unit. This framework formalized the study of energy flow and material exchange within natural systems.

6. (D) Autecology
Autecology is the branch of ecology that focuses on the detailed study of individual species or single populations in relation to their surrounding environment. It investigates physiological adaptations, life histories, behavior patterns, and environmental tolerance limits of a single organism type. In contrast, synecology analyzes complex interactions, community dynamics, and multi-species assemblages across shared geographical regions and ecological niches.

7. (B) Temperature
Temperature is a key abiotic factor that determines the spatial distribution, enzymatic activities, and physiological functions of organisms in an ecosystem. Unlike biotic components like fungi, earthworms, or phytoplankton, temperature represents a non-living physical parameter. It influences metabolic rates, seasonal migrations, and reproductive cycles, heavily defining thermal tolerance zones for diverse living species.

8. (A) I and II only
Ecosystems function as open systems characterized by continuous energy inflows from sunlight and constant loss of heat and waste. They possess distinct structural components, including biotic and abiotic factors, along with functional attributes like energy transfer. However, ecosystems are dynamic rather than static entities, undergoing continuous structural, seasonal, and succession-driven changes over time across landscapes.

9. (D) Biosphere
The biosphere is the global ecological system integrating all living beings and their

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28. (A) P-3, Q-1, R-4, S-2
Biotic components occupy specific functional roles in ecosystem dynamics. Mango trees serve as primary producers synthesizing organic food through photosynthesis. Grasshoppers act as herbivorous primary consumers, while frogs act as secondary consumers preying on insects. Fungi function as essential decomposers, breaking down decaying matter into inorganic nutrients for soil absorption.

29. (A) Plant life of a particular region
Flora refers to the complete assemblage of plant species natively inhabiting a specific geographical region, geological period, or specialized ecosystem. It encompasses all vegetation types, including trees, shrubs, grasses, ferns, and mosses. In ecological studies, flora is analyzed alongside fauna, which represents the animal life occupying the corresponding physical environment.

30. (C) Stratification
Stratification represents a structural feature of biological communities, describing the vertical layering of vegetation species such as canopy trees, understory shrubs, and ground herbs. In contrast, birth rate, death rate, and sex ratio are fundamental demographic attributes of individual species populations, reflecting population growth dynamics, mortality patterns, and reproductive potential within defined habitats.

31. (D) Primary producers
A grazing food chain always originates with autotrophic primary producers, such as green plants, algae, or photosynthetic bacteria. These organisms absorb solar energy to synthesize complex organic compounds via photosynthesis. Herbivorous primary consumers then feed on these producers, initiating the flow of energy and organic nutrients upward through successive carnivorous trophic levels.

32. (C) Grass → Grasshopper → Frog → Snake → Eagle
In a terrestrial grazing food chain, primary producers like grass synthesize organic matter. Herbivorous primary consumers like grasshoppers feed on grass. Secondary consumers like frogs prey on grasshoppers, tertiary consumers like snakes eat frogs, and quaternary top predators like eagles consume snakes. This order represents the sequential transfer of nutrients and energy.

33. (B) Dead organic matter
A detritus food chain originates from dead organic matter, including decaying plant material, animal carcasses, and metabolic waste products. Microorganisms like bacteria and fungi, along with detritivores such as earthworms, feed on this detritus. Energy flows from non-living organic detritus to decomposers and subsequently to predatory organisms that consume these decomposers.

34. (B) 10%
According to Raymond Lindeman's ten percent law, approximately ten percent of the energy entering any given trophic level is transferred and stored as biomass at the next trophic level. The remaining ninety percent is lost during metabolic processes, respiration, movement, and heat dissipation into the surrounding environment, restricting typical food chains to few levels.

35. (A) Raymond Lindeman
American ecologist Raymond Lindeman proposed the ten percent law of energy transfer in 1942 through his seminal work on ecosystem energetics in Cedar Bog Lake. His trophic-dynamic aspect of ecology quantified energy efficiency across food webs, establishing that energy decreases exponentially at higher trophic levels due to metabolic respiratory losses.

36. (C) Food web
A food web is a complex, interconnected network of multiple food chains within an ecosystem. It illustrates how energy and nutrients flow along diverse, overlapping pathways, as organisms frequently consume and are consumed by various species across different trophic levels. Food webs accurately represent real-world ecological feeding relationships compared to linear chains.

37. (A) It enhances ecosystem stability via alternate food paths.
A food web provides multiple interconnected feeding pathways, enhancing ecosystem stability and resilience. If a specific population declines or disappears, predators can switch to alternative prey species within the web without triggering systemic collapse. This trophic redundancy buffers communities against environmental disturbances, maintaining overall energy flow and structural integrity across the ecosystem.

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oceanic primary productivity and sustaining marine food webs globally.

19. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Energy flow in an ecosystem follows a strictly one-way path, entering as solar radiation captured by primary producers during photosynthesis. As energy transfers between trophic levels, a substantial portion dissipates into the environment as metabolic heat energy. This lost heat cannot be recaptured by autotrophs, making energy flow non-cyclical and strictly unidirectional.

20. (C) Earthworm
Earthworms function as detritivores or decomposers in terrestrial ecosystems, breaking down dead organic matter and detritus. In contrast, grass, cyanobacteria, and algae are autotrophic primary producers that synthesize organic matter through photosynthesis at the base trophic level. The earthworm occupies a distinct functional trophic role centered on organic decomposition rather than photosynthetic production.

21. (A) Population
A population consists of a group of interbreeding individuals belonging to the same species that inhabit a defined geographic area at a specific time. Members of a population share common gene pools, compete for similar resources, and interact socially. Demographic characteristics like birth rates, death rates, density, and age distributions define population dynamics over time.

22. (D) A localized biotic community
A localized biotic community refers to an assemblage of interacting populations of different species coexisting within a designated geographic habitat. These multi-species communities interact through competition, predation, mutualism, and commensalism. Unlike single-species populations, biotic communities encompass diverse plant, animal, and microbial populations that collectively shape local biological organization and ecosystem complexity.

23. (B) The functional role of the organism in its environment
An ecological niche describes the complete functional role, biological interactions, and environmental requirements of an organism within its habitat. While a habitat represents the physical address where a species lives, a niche includes its dietary preferences, active hours, reproductive behaviors, resource utilization patterns, and specific contributions to energy flow and nutrient cycling dynamics.

24. (C) Competitive Exclusion Principle
Gause's Competitive Exclusion Principle states that two distinct species competing for identical limited resources cannot coexist indefinitely in the same ecological niche. The species with superior competitive efficiency will eventually outcompete and displace the other. Coexistence is only achieved when competing species adapt through resource partitioning or minor shift in their functional niches.

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25. (D) Ecotone
An ecotone is a physical transition zone between two distinct ecological communities or biomes, such as the area bridging a forest and grassland. It contains conditions intermediate between adjacent ecosystems, fostering unique microclimates. Ecotones often harbor high biodiversity and specialized species capable of utilizing resources from both neighboring biological systems effectively.

26. (A) Edge effect
The edge effect refers to the biological phenomenon where boundary transition zones between adjacent ecosystems display higher population densities, increased species richness, and greater ecological diversity compared to either core habitat. This occurs because ecotones provide diverse microhabitats, rich foraging opportunities, and environmental conditions suitable for species adapted to both adjoining ecological systems.

27. (B) All species in a community have identical ecological niches.
Every biological species in a community occupies a unique ecological niche tailored to its specific structural, physiological, and behavioral adaptations. If two species shared identical niches, competitive exclusion would force one species into extinction or displacement. A shared habitat can host numerous coexisting species precisely because each utilizes different resources and fulfills distinct functional roles.

relationships. It forms a relatively narrow zone where the solid lithosphere, liquid hydrosphere, and gaseous atmosphere overlap and interact to sustain biological life. This interactive realm provides necessary nutrients, water, solar energy, and atmospheric gases essential for organism survival across diverse global biomes.

10. (A) Ecosystem
An ecosystem comprises the biological community of interacting organisms together with the non-living physical environment. Energy flows through trophic structures while chemical nutrients cycle between living organisms and physical abiotic reservoirs. This dynamic equilibrium allows self-sustaining interaction patterns across terrestrial and aquatic environments, distinguishing an ecosystem from a simple habitat, niche, or ecotone.

11. (B) Green plants
Green plants act as primary producers in terrestrial ecosystems because they synthesize organic compounds from atmospheric carbon dioxide and water using light energy. Through photosynthesis, chlorophyll-containing plants produce glucose and biomass, forming the foundational energetic base for all higher trophic levels, including herbivores, carnivores, and decomposers within terrestrial food webs.

12. (B) To convert solar energy into chemical energy via photosynthesis
Autotrophs fulfill the foundational ecological role of converting radiant solar energy into chemical energy stored in organic molecules through photosynthesis. By synthesizing complex carbohydrates from simple inorganic substances like water and carbon dioxide, autotrophs produce the primary biomass that sustains energy requirements for all heterotrophic organisms, including primary consumers and decomposers.

13. (A) Primary consumers
Primary consumers are herbivorous organisms that feed directly on autotrophic primary producers, such as green plants, algae, and phytoplankton. Occupying the second trophic level in a grazing food chain, they convert plant biomass into animal tissue. Examples include grasshoppers, rabbits, deer, and zooplankton, transferring stored solar energy to higher carnivorous levels.

14. (C) They feed on primary consumers and act as carnivores.
Secondary consumers occupy the third trophic level in an ecosystem by feeding directly on primary consumers, making them carnivores or omnivores. They transfer energy from herbivores to higher-level predators in food chains. Examples include frogs feeding on insects, small birds consuming caterpillars, and snakes eating rodents, maintaining structural stability within complex ecological webs.

15. (A) P-3, Q-1, R-2, S-4
Ecological concepts are historically linked with pioneering scientists. Ernst Haeckel coined the term ecology in 1866, while Arthur Tansley introduced ecosystem in 1935. Walter Rosen coined biodiversity in 1985 to describe biological variation. Joseph Grinnell articulated the concept of ecological niche in 1917, highlighting the distinct microhabitat and functional role of species.

16. (C) Decomposers
Decomposers, including heterotrophic fungi and soil bacteria, break down dead organic matter and complex organic detritus into inorganic nutrients. Through extracellular enzyme secretion, these saprophytes absorb simple dissolved compounds while recycling crucial mineral nutrients like nitrogen, phosphorus, and carbon back into the abiotic soil environment, ensuring perpetual nutrient cycling in ecosystems.

17. (B) Soil
Edaphic factors refer specifically to the physical, chemical, and biological properties of soil that influence plant growth and soil organism distribution. Key edaphic components include soil texture, pH, organic matter content, moisture retention, aeration, and mineral composition. These parameters directly govern root anchorage, water intake, and nutrient availability in terrestrial habitats.

18. (D) Phytoplankton
Phytoplankton, including microscopic diatoms and dinoflagellates, serve as the primary producers in open ocean ecosystems. Floating near the sunlit surface waters of the photic zone, these autotrophic organisms convert solar radiation and dissolved inorganic nutrients into organic biomass through photosynthesis, driving

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38. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Decomposers are omitted from specific linear positions in standard grazing food chain diagrams because they operate across all trophic levels simultaneously. By breaking down dead organic waste from producers, herbivores, and carnivores, decomposers release essential inorganic nutrients back into the soil, rendering their functional role ubiquitous rather than restricted to a single level.

39. (B) Biomagnification
Biomagnification refers to the progressive increase in the concentration of toxic, non-biodegradable chemicals within organism tissues at higher trophic levels in a food chain. Persistent synthetic pollutants, such as heavy metals or pesticides, accumulate in body fat because organisms ingest them faster than they metabolize or excrete them, reaching peak toxicity in apex predators.

40. (C) Fish-eating birds
In aquatic ecosystems contaminated with non-biodegradable synthetic pesticides like DDT, biomagnification causes toxin concentrations to increase sequentially up the food chain. Phytoplankton absorb low environmental concentrations, which accumulate in zooplankton, small fish, and larger predatory fish. Consequently, top predators such as fish-eating birds absorb the highest toxic loads, resulting in eggshell thinning.

41. (D) Charles Elton
British ecologist Charles Elton conceptualized ecological pyramids in 1927 to graphically represent the trophic structure, biomass, and energy relationships within ecosystems. Often referred to as Eltonian pyramids, these models arrange producers at the foundational base with successive consumer levels stacked above, illustrating structural decreases in numbers, biomass, or energy at higher levels.

42. (A) 3, 2, 4, 1
An ecological pyramid is structured from base to apex following energy flow sequence. Autotrophic producers occupy the foundational base at level three. Herbivorous primary consumers sit directly above producers at level two. Carnivorous secondary consumers occupy level four, and apex tertiary consumers complete the structure at the top level one, forming the correct order.

43. (B) Pyramid of Energy
The pyramid of energy is always upright and can never be inverted in any natural ecosystem. This occurs because energy continuously decreases at higher trophic levels due to metabolic heat dissipation and entropy, as mandated by the second law of thermodynamics. Only a fraction of available energy transforms into biomass for higher consumers.

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44. (B) Inverted
In a single large tree ecosystem, the pyramid of numbers is inverted because one massive producer tree supports thousands of herbivorous insects. These insects in turn provide food for a smaller number of insectivorous birds, and few parasitic organisms. Consequently, the base contains a numerical value of one, expanding into higher counts above.

45. (A) P-3, Q-4, R-2, S-1
Ecological pyramids reflect structural relationships across diverse environments. Grassland ecosystems feature upright pyramids of numbers due to abundant grass stems supporting fewer herbivores. Single tree ecosystems display inverted pyramids of numbers. Forest ecosystems show upright biomass pyramids, whereas aquatic pond systems possess inverted biomass pyramids because phytoplankton reproduce rapidly despite low instantaneous biomass.

46. (C) Standing crop
Standing crop refers to the total mass of living organic material present at a given trophic level in a specified area at a particular time. It can be expressed as biomass weight or organism numbers. Unlike the standing state, which measures inorganic nutrient quantities, standing crop represents living biotic material actively participating in ecosystem dynamics.

47. (D) Phytoplankton biomass is less than consumer biomass.
The pyramid of biomass in marine ecosystems is inverted because microscopic primary producers, such as phytoplankton, possess extremely short lifespans and rapid turnover rates. Their instantaneous standing biomass at any given moment is significantly smaller than the biomass of long-lived zooplankton and fish consumers

94. A secondary pollutant is formed when primary pollutants react in the atmosphere. Which of the following is a secondary air pollutant?
(A) Sulphur dioxide
(B) Nitrogen oxide
(C) Ozone (tropospheric)
(D) Particulate matter

95. Consider the following gases present in the Earth's atmosphere:
I. Carbon dioxide (CO_2)
II. Methane (CH_4)
III. Nitrogen (N_2)
Which of the above statement(s) is/are correct regarding gases responsible for the Greenhouse Effect?
(A) I and III only
(B) II and III only
(C) I and II only
(D) I, II, and III

96. What does Biological Oxygen Demand (BOD) primarily measure in a water body?
(A) The total amount of oxygen produced by aquatic plants during peak photosynthesis
(B) The total concentration of dissolved inorganic minerals and salts in water
(C) Oxygen consumed by microbes to decompose organic waste
(D) The average volumetric rate of surface water flow across a river channel

97. If a river has a very high BOD value, it indicates that the river is?
(A) Extremely pure and clean
(B) Highly polluted with organic waste
(C) Completely devoid of any living organisms
(D) Very cold

98. The excessive addition of chemical nutrients (like nitrates and phosphates) into a water body causing dense growth of plant life and algal blooms is called?
(A) Biomagnification
(B) Bioremediation
(C) Sedimentation
(D) Eutrophication

99. Why do algal blooms often lead to massive fish deaths in a lake?
(A) The algae rapidly deplete the dissolved oxygen in the water.
(B) The algae physically attack the fish.
(C) The algae increase the water transparency too much.
(D) The algae decrease the water temperature drastically.

100. Which organism is widely regarded as an excellent natural bioindicator of air pollution, specifically for sulphur dioxide (SO_2) concentration?
(A) Ferns
(B) Earthworms
(C) Lichens
(D) Mushrooms

101. The abbreviation SPM in the context of air pollution stands for?
(A) Suspended Particulate Matter
(B) Standard Pollution Measure
(C) Solid Particulate Matter
(D) Sulphur Phosphorus Mixture

102. Given below are two statements, one labeled as Assertion (A) and the other as Reason (R).
Assertion (A): The presence of an ozone layer in the stratosphere is highly beneficial for life on Earth.
Reason (R): Stratospheric ozone completely absorbs harmful ultraviolet (UV) radiation coming from the sun.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

103. The international environmental treaty known as the Montreal Protocol was signed primarily to control?
(A) Global industrial emissions of atmospheric greenhouse gases
(B) Production and use of Ozone Depleting Substances
(C) International trade in endangered wild species of flora and fauna
(D) Transboundary movement and disposal of hazardous chemical waste

104. The Kyoto Protocol is an international agreement linked to which major environmental issue?
(A) Prevention of global soil degradation and desertification
(B) Protection and wise use of international wetlands habitats
(C) Reducing greenhouse gases to fight climate change

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exceptionally high rates of primary productivity due to efficient nutrient recycling between host corals and photosynthetic zooxanthellae algae.

58. (A) Stratification
Stratification refers to the distinct vertical layering of vegetation and biological species within an ecosystem based on light and habitat requirements. In a mature forest, stratification forms defined structural strata, including upper canopy trees, understory trees, tall shrubs, and ground-level mosses or herbs. This arrangement optimizes resource partitioning among coexisting botanical species.

59. (B) Chinkara
The Chinkara, or Indian Gazelle, is the official state animal of Rajasthan under the wildlife category. Highly adapted to arid and semi-arid desert environments, it survives with minimal free water intake by deriving moisture from vegetation and dew. Its agility, sandy coat coloration, and efficient water conservation mechanisms enable survival across harsh desert landscapes.

60. (B) Lotic Ecosystem - Pond
Lotic ecosystems encompass flowing or running aquatic environments, such as rivers, streams, and creeks where water flows continuously. Ponds, along with lakes and reservoirs, are categorized as lentic ecosystems because they contain standing or static water bodies. Marine environments, terrestrial biomes, and artificial aquariums represent accurate pairs of natural and human-engineered systems.

61. (A) Homeostasis
Homeostasis in an ecosystem refers to its intrinsic capacity to maintain structural stability, functional balance, and internal equilibrium despite external environmental fluctuations or minor disturbances. Driven by negative feedback loops, self-regulatory mechanisms allow ecosystems to control population sizes, nutrient balances, and energy flows, ensuring long-term resilience and ecological resistance against transient stress factors.

62. (A) P-3, Q-4, R-2, S-1
Ecosystems are classified into distinct structural types based on habitat characteristics and human influence. Terrestrial biomes like forests represent natural land-based ecosystems, while standing lakes represent natural lentic aquatic systems. Flowing rivers constitute natural lotic systems, and cultivated crop fields exemplify artificial or human-managed ecosystems controlled by agricultural interventions.

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63. (D) Ecological succession
Ecological succession is the gradual, predictable process of directional changes in species composition, community structure, and environmental conditions of a specific area over time. Initiated after disturbance or barren land exposure, succession proceeds through intermediate seral stages until a stable, self-perpetuating climax community achieves long-term equilibrium with the local climatic environment.

64. (C) Pioneer species
Pioneer species are the first opportunistic organisms to colonize a previously barren, unoccupied habitat lacking soil, such as bare rocks, cooled volcanic lava, or sand dunes. Lichens and mosses are classic pioneer species in primary succession; they weather rock surfaces into primitive soil through organic acid secretion, creating conditions suitable for secondary plants.

65. (B) Ground cover → Shrubs → Understory trees → Canopy trees
Vertical stratification in a mature forest ecosystem organizes plant species systematically based on light exposure from ground level upward. The bottom tier consists of ground cover like mosses and herbs, followed by a shrub layer, an understory of small trees, and an upper canopy composed of mature tall trees dominating light absorption.

66. (D) Climax community
A climax community represents the ultimate, stable stage of ecological succession in a given geographical area. Possessing maximum biomass, species diversity, and complex food webs, it remains in dynamic equilibrium with the prevailing regional climate. Unlike temporary pioneer or seral stages, a climax community continues to self-perpetuate unless disrupted by major environmental cataclysms.

67. (A) Forest recovery following a severe wildfire
Secondary succession occurs in areas where a pre-existing ecological community was disturbed or destroyed by events like wildfires, flooding,

CHAPTER 14

Energy Flow and Biogeochemical Cycles

1. What is the primary source of energy for almost all ecosystems on Earth?
(A) Geothermal energy
(B) Solar energy
(C) Chemical energy from the soil
(D) Wind energy

2. Which of the following statements best describes the nature of energy flow in an ecosystem?
(A) It is cyclic and reversible.
(B) It is multidirectional and random.
(C) It flows from consumers to producers.
(D) It is unidirectional and non-cyclic.

3. What percentage of the incident solar radiation is considered Photosynthetically Active Radiation (PAR)?
(A) Less than 50 percent
(B) Exactly 100 percent
(C) Between 80 to 90 percent
(D) Less than 1 percent

4. Out of the total Photosynthetically Active Radiation (PAR), what percentage is typically captured by plants for photosynthesis?
(A) 10 to 20 percent
(B) 50 to 60 percent
(C) 2 to 10 percent
(D) 100 percent

5. The unidirectional flow of energy and the continuous requirement of energy in an ecosystem is governed by which fundamental principle of physics?
(A) Laws of Thermodynamics
(B) Newton's Laws of Motion
(C) Law of Conservation of Mass
(D) Archimedes' Principle

6. In an ecosystem, green plants and photosynthetic bacteria that produce their own food from solar energy are known as:
(A) Primary consumers
(B) Decomposers
(C) Secondary consumers
(D) Producers

7. A specific place occupied by an organism in a food chain based on its source of nutrition is called its:
(A) Ecological niche
(B) Trophic level
(C) Habitat
(D) Biome

8. Match the organisms in List I with their corresponding trophic levels in List II.
List I: Organisms
P. Green Plants
Q. Herbivores (e.g., Grasshopper)
R. Primary Carnivores (e.g., Frog)
S. Top Carnivores (e.g., Eagle)
List II: Trophic Levels
1. Second Trophic Level
2. Fourth Trophic Level
3. First Trophic Level
4. Third Trophic Level
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-1, S-4

9. Which of the following is NOT a producer in an aquatic ecosystem?
(A) Phytoplankton
(B) Algae
(C) Submerged plants
(D) Zooplankton

10. As energy moves from one trophic level to the next, a significant amount is lost to the environment primarily in the form of:
(A) Heat
(B) Light
(C) Sound
(D) Chemical bonds

11. Who proposed the "Ten Percent Law" of energy transfer in food chains?
(A) Charles Darwin
(B) Raymond Lindeman
(C) Arthur Tansley
(D) Gregor Mendel

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77. (A) High species richness, high endemism, and severe habitat threat
A designated biodiversity hotspot is an ecological region characterized by extraordinary levels of species richness and high endemism, combined with severe threats of habitat destruction. To qualify as a global hotspot, a region must harbor at least 1,500 endemic vascular plant species and have lost at least 70% of its primary native vegetation.

78. (A) P-4, Q-2, R-3, S-1
In-situ conservation protects wild species within their natural habitats, exemplified by terrestrial National Parks and Marine Protected Areas. Ex-situ conservation involves safeguarding threatened species outside their natural environments, such as preserving endangered plant flora in Botanical Gardens or maintaining animal populations in controlled Zoological Parks to ensure species survival and breeding.

79. (D) Orans
In Rajasthan, Orans are traditional community-conserved sacred groves dedicated to local deities or religious figures. Supported by cultural traditions, local communities prohibit tree cutting and hunting within these forest patches. Consequently, Orans serve as vital in-situ biodiversity refuges, protecting native desert flora, preserving soil moisture, and providing habitat for local wildlife.

80. (C) Human-driven habitat destruction and loss
Human-driven habitat destruction, degradation, and fragmentation represent the leading primary cause of global species extinction today. Activities such as industrial agricultural expansion, urban sprawl, deforestation, mining, and infrastructure development destroy natural ecosystems, depriving native flora and fauna of essential shelter, foraging territories, and interbreeding opportunities necessary for sustained species survival.

81. (B) Dodo
The Dodo was a flightless bird endemic to the island of Mauritius that became completely extinct during the late seventeenth century. Human exploitation, habitat destruction, and the introduction of invasive mammalian predators like rats and pigs decimated its population, making the Dodo a prominent global symbol of human-caused species extinction events.

82. (D) Siberian Crane
Keoladeo Ghana National Park in Bharatpur, Rajasthan, is a world-renowned Ramsar wetland famous as a wintering habitat for migratory waterfowl. Historically, it served as the major wintering site in India for the endangered Siberian Crane, which migrated thousands of kilometers from Arctic Russia to escape extreme winter conditions before regional population declines occurred.

83. (A) Bengal Tiger
Ranthambore National Park in Rajasthan is internationally renowned for its dedicated efforts under Project Tiger to conserve the apex predator Bengal Tiger. Its diverse terrain of dry deciduous forests and open grasslands provides ideal habitat, water bodies, and prey species like sambar and chital, sustaining a thriving tiger population monitored for wildlife conservation research.

84. (C) Jaisalmer and Barmer
Desert National Park, one of India's largest protected areas, spans across the arid Jaisalmer and Barmer districts of western Rajasthan. It protects fragile sand dune ecosystems and xerophytic flora, while serving as a crucial sanctuary for the critically endangered state bird, Godawan, along with desert foxes, chinkaras, and rare native desert reptiles.

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85. (A) Sita Mata
Sita Mata Wildlife Sanctuary in Pratapgarh district is celebrated for its dense teak forests and rare flying squirrel population, but it is not designated as a Tiger Reserve. Sariska, Mukundra Hills, and Ramgarh Vishdhari are officially declared Tiger Reserves in Rajasthan under Project Tiger, forming critical protected corridors for tiger conservation.

86. (D) Blackbuck
Tal Chhapar Wildlife Sanctuary, situated in the Churu district of Rajasthan, is famous for its open flat grassland ecosystem that supports a large population of Blackbucks. The sanctuary provides specialized feeding grounds and shelter for these elegant antelopes, while also attracting numerous resident and migratory raptor birds throughout the year.

(A) Mineral nutrients continuously circulate within the living and non-living ecosystem components.
(B) Energy is recycled by decomposers back to producers.
(C) Radiant energy flows through the ecosystem and ultimately dissipates into space.
(D) Microbial decomposers convert organic matter into inorganic nutrient compounds.

24. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The pyramid of energy is always upright in any ecosystem.
Reason (R): When energy flows from one trophic level to the next, some energy is always lost as heat at each step.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

25. The total rate of photosynthesis including the organic matter used up in respiration during the measurement period is defined as:
(A) Net Primary Productivity
(B) Secondary Productivity
(C) Net Community Productivity
(D) Gross Primary Productivity

26. Which mathematical equation correctly relates Gross Primary Productivity (GPP) and Net Primary Productivity (NPP)?
(A) NPP = GPP - Respiration
(B) NPP = GPP + Respiration
(C) GPP = NPP - Respiration
(D) NPP = Respiration - GPP

27. In the context of primary productivity, what does the term 'R' signify in the equation GPP - R = NPP?
(A) Reproductive output
(B) Respiration losses
(C) Radiation loss
(D) Recycling rate

28. Which type of productivity is defined as the rate of formation of new organic matter by consumers (herbivores/carnivores)?
(A) Gross Primary Productivity
(B) Secondary Productivity
(C) Net Primary Productivity
(D) Tertiary Productivity

29. Which of the following ecosystems generally has the highest annual net primary productivity?
(A) Tropical rain forest
(B) Arid desert ecosystem
(C) Deep ocean environment
(D) Arctic tundra biome

30. Match the ecosystem in List I with its relative productivity level in List II.
List I: Ecosystems
P. Desert
Q. Coral Reef
R. Open Ocean
S. Estuary
List II: Productivity Levels
1. Extremely high productivity
2. High productivity
3. Very low productivity due to lack of water
4. Low productivity despite large total area
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-3, Q-4, R-1, S-2

31. In arid regions of Rajasthan, net primary productivity is relatively low primarily due to the scarcity of:
(A) Sunlight
(B) Oxygen
(C) Carbon dioxide
(D) Water

32. The mass of living material at a particular trophic level at a given time is known as:
(A) Standing state
(B) Biomass gradient
(C) Standing crop
(D) Gross productivity

33. The measurement of biomass in an ecosystem is most accurate if expressed in terms of:
(A) Fresh weight
(B) Dry weight
(C) Volume
(D) Length of organisms

34. What approximate percentage of the dry weight of living organisms is composed of carbon?
(A) 10 percent
(B) 25 percent
(C) 49 percent
(D) 71 percent

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97. (B) Highly polluted with organic waste
A high Biological Oxygen Demand value indicates that a water body contains excessive amounts of biodegradable organic pollution, such as sewage or agricultural runoff. Microbes consume massive amounts of dissolved oxygen to decompose this organic matter, resulting in oxygen depletion that severely degrades water quality and threatens the survival of aquatic animal life.

98. (D) Eutrophication
Eutrophication is the ecological process where water bodies receive excessive nutrient inputs, particularly nitrates and phosphates from agricultural runoff and sewage. This nutrient enrichment triggers explosive growth of algae and aquatic plants, leading to dense algal blooms. Subsequent algal decomposition by bacteria severely depletes dissolved oxygen, causing hypoxia and aquatic fauna mortality.

99. (A) The algae rapidly deplete the dissolved oxygen in the water.
Algal blooms lead to massive fish mortality primarily because the rapid growth and subsequent decay of excessive algal biomass severely deplete dissolved oxygen in water bodies. When dense algae die, aerobic decomposer bacteria proliferate rapidly, consuming available dissolved oxygen during decay. This severe hypoxic condition starves fish and aquatic animals of oxygen.

100. (C) Lichens
Lichens are delicate symbiotic organisms composed of fungi and algae that serve as excellent natural bioindicators of air quality, particularly sensitive to sulphur dioxide pollution. Lacking roots and protective cuticles, lichens absorb water and nutrients directly from the air, making them highly susceptible to atmospheric toxins, which leads to their disappearance in polluted urban regions.

101. (A) Suspended Particulate Matter
Suspended Particulate Matter refers to tiny solid particles or liquid droplets floating in the atmosphere, including dust, smoke, soot, pollen, and ash. Ranging in size from sub-micron particles to larger dust grains, SPM significantly reduces air clarity and penetrates deep into human respiratory tracts, causing serious respiratory and cardiovascular health complications.

102. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
The stratospheric ozone layer is vital for life on Earth because it functions as a protective shield absorbing harmful high-energy solar ultraviolet radiation. By filtering out destructive UV-B rays, stratospheric ozone prevents severe ecological damage, including increased incidence of skin cancers, eye cataracts, genetic mutations, and reduced photosynthetic productivity in marine and terrestrial plants.

103. (B) Production and use of Ozone Depleting Substances
The Montreal Protocol is an international environmental treaty adopted in 1987 to protect the stratospheric ozone layer. It regulates the global production and consumption of ozone-depleting substances, such as chlorofluorocarbons and halons. By phasing out these synthetic chemicals, the treaty has successfully aided the gradual recovery and stabilization of global stratospheric ozone levels.

104. (C) Reducing greenhouse gases to fight climate change
The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. Adopted in 1997, it commits industrialized countries to binding emission reduction targets for key greenhouse gases, including carbon dioxide and methane, to mitigate anthropogenic global warming and combat long-term global climate change impacts.

105. (A) P-1, Q-2, R-3, S-4
Wildlife Sanctuaries in Rajasthan are located in specific geographical districts. Sita Mata Sanctuary, famous for flying squirrels, is situated in Pratapgarh. Tal Chhapar, known for blackbucks, resides in Churu. Mount Abu Sanctuary is located in Sirohi's high-altitude hills, while Ramgarh Vishdhari Sanctuary, a declared tiger reserve, is located in Bundi district.

106. (A) Brundtland Commission (Our Common Future)
Sustainable development was formally defined in the 1987 landmark report entitled Our Common Future, published by the World Commission on Environment and Development, known as the Brundtland Commission. The definition emphasizes balancing socio-economic progress with environmental preservation to ensure

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87. (B) Core zone
Within a designated Biosphere Reserve under legal protection, the core zone is strictly legally protected and devoted exclusively to wildlife conservation. All human activities, including resource extraction, farming, timber collection, tourism, and settlement, are completely prohibited in the core zone to ensure pristine natural ecosystem processes proceed without anthropogenic disturbance or degradation.

88. (B) I and II only
Sariska is an officially designated Tiger Reserve in Rajasthan, and Keoladeo National Park is recognized as a Ramsar Wetland Site of international importance. However, Desert National Park protects desert wildlife like the Great Indian Bustard and Chinkara, not Asiatic Lions, which are naturally confined to Gir National Park in Gujarat.

89. (B) 1973
Project Tiger was launched by the Government of India in April 1973 from Jim Corbett National Park. Aimed at stemming the rapid decline of wild tiger populations, the initiative established dedicated tiger reserves across the country to protect natural habitats, prevent poaching, and ensure viable populations of Bengal tigers in their natural environments.

90. (A) Sanctuaries permit limited human activities, whereas National Parks prohibit all private rights.
Wildlife Sanctuaries permit limited regulated human activities such as grazing, timber harvesting, and private land ownership, provided they do not harm wildlife. In contrast, National Parks enjoy higher protection where all private rights are completely extinguished, human interference is strictly prohibited, and habitat protection is enforced under national legislation for overall ecosystem preservation.

91. (B) Carbon monoxide
Carbon monoxide is a primary air pollutant because it is emitted directly into the atmosphere from identifiable sources, such as incomplete combustion of fossil fuels in motor vehicles and industrial plants. In contrast, secondary pollutants like ozone and peroxyacetyl nitrate form in the air through complex chemical reactions among primary pollutants in solar radiation.

92. (A) P-1, Q-2, R-3, S-4
Environmental pollutants cause distinct pathological conditions. Industrial mercury poisoning causes Minamata disease, affecting central nervous systems. Cadmium exposure leads to Itai-Itai disease, causing severe joint and skeletal pain. Excess nitrate in drinking water causes methemoglobinemia or blue-baby syndrome, while high fluoride levels induce skeletal and dental fluorosis in human populations.

93. (A) Sulphur dioxide and Nitrogen oxides
Acid rain is primarily caused by atmospheric emissions of sulphur dioxide and nitrogen oxides released during fossil fuel combustion in industrial plants and motor vehicles. These gases react with atmospheric water vapor, oxygen, and oxidants to form sulphuric acid and nitric acid, which fall as precipitation, causing severe acidification of aquatic and terrestrial ecosystems.

94. (C) Ozone (tropospheric)
Tropospheric ozone is a secondary air pollutant that is not emitted directly from industrial chimneys or vehicle exhausts. Instead, it forms in the atmosphere when primary pollutants, specifically nitrogen oxides and volatile organic compounds, react in the presence of sunlight. In contrast, sulphur dioxide, nitrogen oxide, and particulate matter represent direct primary emissions.

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95. (C) I and II only
Carbon dioxide and methane are potent greenhouse gases that trap infrared radiation emitted from the Earth's surface, contributing significantly to global warming. In contrast, atmospheric nitrogen is a diatomic homonuclear gas that does not absorb infrared heat radiation. Thus, nitrogen plays no direct role in driving the atmospheric greenhouse effect mechanism.

96. (C) Oxygen consumed by microbes to decompose organic waste
Biological Oxygen Demand measures the amount of dissolved oxygen required by aerobic microorganisms to biochemically decompose organic waste present in a water sample over a specified period. High demand indicates elevated concentrations of biodegradable organic pollutants, which consume available dissolved oxygen during aerobic microbial decomposition, stressing fish and aquatic organisms.

conservation and wise use of wetlands worldwide. It provides a framework for national action and international cooperation to preserve ecologically critical wetland habitats, including lakes, rivers, marshes, estuaries, and coastal lagoons that support rich aquatic biodiversity.

117. (A) Sambhar Salt Lake
Sambhar Salt Lake is a designated Ramsar Wetland Site of international importance located in Rajasthan. As India's largest inland saltwater lake, it provides a specialized hyper-saline aquatic habitat that supports unique algal organisms, brine shrimp, and thousands of wintering migratory birds, including large populations of flamingos that feed on its biological resources.

118. (A) I and II only
Promoting unleaded petrol eliminates airborne lead pollution from motor vehicle exhausts, while installing electrostatic precipitators in power plant chimneys effectively captures fine particulate matter before smoke discharge. In contrast, discharging untreated industrial effluents directly into rivers exacerbates water pollution, making only the first two measures correct for reducing environmental pollution.

119. (B) Dobson Units (DU)
The total thickness of the stratospheric ozone layer in an atmospheric column above the Earth's surface is measured in Dobson Units. One Dobson Unit corresponds to a layer of pure ozone 0.01 millimeters thick at standard temperature and pressure. Average global atmospheric ozone levels typically measure around three hundred Dobson Units.

120. (C) Expeditious disposal of environmental protection cases
The National Green Tribunal was established in India under the National Green Tribunal Act of 2010 for the expeditious disposal of cases relating to environmental protection, forest conservation, and natural resource enforcement. Possessing specialized judicial power, the NGT ensures speedy environmental justice, reduces burden on regular courts, and mandates financial compensation for environmental damages.

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current resource utilization does not compromise the developmental capabilities of future human generations.

107. (B) Using biological organisms to clean up polluted environments
Bioremediation is a biotechnology process that utilizes living organisms, primarily specialized bacteria, fungi, or green plants, to remove, neutralize, or degrade hazardous environmental pollutants from contaminated soil and water. Microorganisms metabolize toxic organic compounds into non-toxic substances like water and carbon dioxide, offering an eco-friendly approach to environmental cleanup.

108. (B) Khejri trees
Amrita Devi Bishnoi is legendary in environmental history for leading the 1730 Khejarli movement in Rajasthan, where she and 362 other Bishnoi community members sacrificed their lives clinging to sacred Khejri trees to protect them from being felled by royal soldiers. Her martyrdom inspires contemporary forest protection and environmental conservation ethics across India.

109. (A) Chipko Movement
The Chipko Movement was a non-violent environmental campaign initiated in the Garhwal Himalayas of Uttarakhand during the early 1970s. Local villagers, particularly women, embraced forest trees to physically prevent logging contractors from felling them. This grassroots movement highlighted forest rights, prevented hillside soil erosion, and inspired global eco-feminist and community forest conservation movements.

110. (A) 2, 4, 1, 3
The waste management hierarchy ranks strategies according to environmental preference. Source reduction is the most effective strategy, followed by directly reusing materials. Recycling processed waste into new materials ranks third, while disposing waste into sanitary landfills represents the least desirable, final option due to environmental pollution and resource loss associated with permanent dumping.

111. (D) Carbon sequestration
Carbon sequestration refers to the long-term capture and storage of atmospheric carbon dioxide in natural carbon sinks, such as forests, soils, oceans, and underground geological formations. By removing greenhouse gases from the atmosphere and storing them permanently, carbon sequestration acts as a major mitigation strategy to reduce global warming and combat climate change.

112. (C) Supply of food, timber, and fresh water
Provisioning services represent the direct, tangible material products obtained from ecosystems to support human livelihoods and survival. Examples include freshwater supplies, food crops, timber for construction, medicinal plants, raw fiber, and fuel wood. These direct natural provisions contrast with abstract ecological functions like atmospheric regulation, nutrient cycling, or recreational ecosystem services.

113. (B) Regulating service
Crop pollination by wild bees, butterflies, and other insects is classified as an ecosystem regulating service. Regulating services are benefits obtained from the natural regulation of ecosystem processes, including climate regulation, flood control, water purification, and disease control. Animal pollination maintains agricultural crop yields and natural vegetation reproduction without artificial technological intervention.

114. (C) 1986
The Environment Protection Act was enacted by the Parliament of India in 1986 in the wake of the Bhopal Gas Tragedy. Operating as comprehensive umbrella legislation, it empowers the central government to coordinate environmental protection activities, set air and water quality standards, regulate industrial pollution, and protect overall environmental quality nationwide.

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115. (A) P-1, Q-2, R-3, S-4
India enacted foundational environmental legislation to protect ecosystems. The Wildlife Protection Act was passed in 1972 to safeguard fauna and flora. The Water Act followed in 1974 to prevent aquatic pollution. The Forest Conservation Act was enacted in 1980 to limit deforestation, while the Air Act was established in 1981.

116. (C) Wetlands
The Ramsar Convention is an international treaty adopted in Ramsar, Iran, in 1971 to promote the

12. According to the Ten Percent Law, what fraction of energy is transferred from one trophic level to the next higher trophic level?
(A) 1 percent
(B) 10 percent
(C) 50 percent
(D) 90 percent

13. If 10,000 Joules of solar energy is captured by grass, how much energy will be available to the secondary consumer (e.g., a frog eating a grasshopper) in the food chain?
(A) 1000 Joules
(B) 100 Joules
(C) 10 Joules
(D) 1 Joule

14. Why are food chains in nature generally limited to 3 or 4 trophic levels?
(A) Apex predators become physically too large to hunt efficiently in habitats.
(B) Natural ecosystems lack sufficient physical space to harbor more species.
(C) Energy loss at each step leaves insufficient energy for higher levels.
(D) Heterotrophic decomposers consume all remaining energy before consumers.

15. Consider the following statements regarding energy flow in ecosystems:
I. Energy flow is strictly unidirectional.
II. Decomposers play no role in an ecosystem.
III. Energy transfer is highly efficient, with 90% moving to the next level.
Which of the above statement(s) is/are correct?
(A) Only I
(B) I and II
(C) Only II and III
(D) I, II, and III

16. The ratio of energy transferred from one trophic level to the next, expressed as a percentage, is known as:
(A) Ecological succession
(B) Net primary productivity
(C) Ecological efficiency
(D) Biomagnification

17. Which of the following trophic levels always possesses the maximum total amount of energy in a standard ecosystem?
(A) Primary consumers
(B) Producers
(C) Secondary consumers
(D) Top carnivores

18. Choose the correct sequence of energy flow in a terrestrial ecosystem.
(A) Sun → Carnivore → Herbivore → Producer
(B) Producer → Sun → Carnivore → Herbivore
(C) Herbivore → Carnivore → Producer → Sun
(D) Sun → Producer → Herbivore → Carnivore

19. An upright pyramid of energy implies that:
(A) Energy decreases at each successive trophic level.
(B) Energy increases at each successive trophic level.
(C) Energy remains constant across all trophic levels.
(D) Producers consistently possess the lowest energy content.

20. Match the ecological pyramids in List I with their general characteristics in List II.
List I: Ecological Pyramids
P. Pyramid of Energy
Q. Pyramid of Biomass in a forest
R. Pyramid of Biomass in an ocean
S. Pyramid of Numbers in a grassland
List II: Characteristics
1. Usually upright
2. Always upright
3. Generally inverted
4. Upright
(A) P-2, Q-4, R-3, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-4, S-2

21. Which organism acts as both a primary and secondary consumer depending on its diet?
(A) Human
(B) Cow
(C) Lion
(D) Rabbit

22. What happens to the energy that is not transferred to the next trophic level?
(A) It is destroyed completely during metabolic activity.
(B) It is continuously recycled back to solar radiation.
(C) It is permanently locked and stored within the soil.
(D) It is lost as heat during metabolic respiration.

23. Identify the incorrect statement concerning ecosystem dynamics.

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or deforestation, but where fertile soil and organic seed banks remain intact. Because soil is already present, secondary succession proceeds significantly faster than primary succession, allowing rapid vegetation recovery and forest re-establishment over time.

68. (C) Carrying capacity
Carrying capacity represents the maximum population size of a species that an environment can sustainably support indefinitely, given available resources such as food, water, shelter, and habitat space. Represented by the symbol K, carrying capacity is determined by environmental resistance factors that prevent unchecked exponential growth, keeping populations bounded within sustainable limits.

69. (A) Increased soil erosion and loss of biodiversity
Large-scale deforestation leads directly to severe environmental degradation, including accelerated topsoil erosion, increased runoff, and substantial loss of biological diversity. Tree roots naturally anchor soil structures and promote water infiltration. Removing forest canopy leaves topsoil exposed to wind and rain erosion, while simultaneously destroying natural habitats critical for terrestrial wildlife species survival.

70. (D) Slash-and-burn farming
Jhum cultivation is a traditional agricultural practice widely known as slash-and-burn farming. Farmers clear forest land by cutting and burning vegetation to create nutrient-rich ash seedbeds for crops. After a few cultivation cycles exhaust soil fertility, farmers abandon the plot for new forest lands, leading to severe deforestation and soil degradation when fallow periods shorten.

71. (B) Genetic, Species, and Ecosystem levels
Biodiversity represents the biological variety and variability of life across three fundamental levels of organization: genetic diversity within individual species populations, species diversity reflecting the number and abundance of distinct species in a habitat, and ecosystem diversity encompassing the variety of biological communities, habitats, and ecological processes operating across biomes globally.

72. (C) Edward O. Wilson
American sociobiologist Edward O. Wilson popularized the term biodiversity during the mid-1980s through seminal publications and public advocacy. Often dubbed the Father of Biodiversity, his influential work highlighted global species richness, warned against accelerated extinction crises driven by human activities, and advanced scientific frameworks for international conservation biology and habitat preservation policies worldwide.

73. (D) Western Ghats
The Western Ghats mountain range running parallel to India's western coast is recognized globally as a critical biodiversity hotspot. It exhibits exceptional species richness and high levels of endemism across plant, amphibian, reptile, and mammal taxa. Dense tropical evergreen forests within this region harbor numerous specialized species found nowhere else on Earth.

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74. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
The Great Indian Bustard is classified as critically endangered due to drastic population declines brought about by habitat fragmentation, agricultural expansion, overhead power line collisions, and human encroachment across its native arid grasslands in Rajasthan and Gujarat. Targeted conservation measures are required to protect its remaining native habitats and prevent complete species extinction.

75. (B) Endemic species
Endemic species are native organisms whose geographical distribution is strictly restricted to a defined, specific region, such as an island, mountain range, or distinct ecosystem, and are found nowhere else naturally on Earth. Due to localized distributions, endemic species are exceptionally vulnerable to habitat destruction, climate change, and invasive species introduction.

76. (B) IUCN
The Red Data Book is published by the International Union for Conservation of Nature, an international organization dedicated to natural resource conservation. It provides detailed global assessments monitoring the conservation status, population trends, threats, and extinction risks of worldwide biological species, classifying threatened species into standardized risk categories ranging from vulnerable to critically endangered.

35. Consider the following statements about productivity:
I. Primary productivity depends on the plant species inhabiting a particular area.
II. Environmental factors, availability of nutrients, and photosynthetic capacity do not affect productivity.
III. NPP is the available biomass for the consumption of heterotrophs.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II, and III

36. Which of the following best defines a biogeochemical cycle?
(A) The one-way directional flow of energy through producers, consumers, and decomposers.
(B) The gradual geological processes responsible for forming metamorphic rock layers.
(C) The movement of nutrient elements through biotic and abiotic components.
(D) The cyclical changing of climatic seasons on Earth resulting from planetary orbit.

37. Biogeochemical cycles are broadly classified into two major types:
(A) Gaseous and Sedimentary cycles
(B) Active and Passive cycles
(C) Biological and Chemical cycles
(D) Renewable and Non-renewable cycles

38. The reservoir pool for gaseous types of nutrient cycles is generally located in the:
(A) Earth's crust
(B) Deep ocean trenches
(C) Mantle
(D) Atmosphere or ocean

39. The reservoir for sedimentary nutrient cycles is primarily found in the:
(A) Stratosphere
(B) Earth's crust
(C) Troposphere
(D) Ionosphere

40. Arrange the following organisms in a correct food chain sequence for a terrestrial ecosystem.
1. Snake
2. Grass
3. Hawk
4. Frog
5. Grasshopper
(A) $2 \rightarrow 5 \rightarrow 4 \rightarrow 1 \rightarrow 3$
(B) $2 \rightarrow 4 \rightarrow 5 \rightarrow 1 \rightarrow 3$
(C) $5 \rightarrow 2 \rightarrow 4 \rightarrow 3 \rightarrow 1$
(D) $2 \rightarrow 5 \rightarrow 1 \rightarrow 4 \rightarrow 3$

41. Which of the following is a classic example of a sedimentary biogeochemical cycle?
(A) Carbon cycle
(B) Nitrogen cycle
(C) Oxygen cycle
(D) Phosphorus cycle

42. Which of the following is an example of a gaseous biogeochemical cycle?
(A) Carbon cycle
(B) Sulphur cycle
(C) Phosphorus cycle
(D) Calcium cycle

43. The amount of nutrients, such as carbon, nitrogen, phosphorus, and calcium, present in the soil at any given time is referred to as the:
(A) Standing crop
(B) Standing state
(C) Climax community
(D) Primary productivity

44. Identify the incorrect statement regarding nutrient cycling.
(A) Essential nutrient elements are never permanently lost from dynamic natural ecosystems.
(B) Nutrient movement is completely independent of soil moisture and pH.
(C) Bioavailable nutrients are continuously recycled through ecosystems over infinite time.
(D) The atmospheric or sedimentary reservoir pool buffers deficits from influx imbalances.

45. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Matter is conserved and recycled in an ecosystem, while energy flows in a single direction.
Reason (R): Decomposers break down organic matter into inorganic nutrients but energy is dissipated as heat.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.

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(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

46. What constitutes the largest global reservoir of carbon on Earth?
(A) The atmosphere
(B) Terrestrial biosphere (plants and soil)
(C) Oceans
(D) Fossil fuels

47. Approximately what percentage of global carbon is found dissolved in the oceans?
(A) 10 percent
(B) 30 percent
(C) 50 percent
(D) 71 percent

48. Atmospheric carbon dioxide constitutes roughly what percentage of the total global carbon pool?
(A) 1 percent
(B) 10 percent
(C) 21 percent
(D) 50 percent

49. Which biological process is responsible for the removal of carbon dioxide from the atmosphere and fixing it into organic compounds?
(A) Cellular respiration
(B) Photosynthesis
(C) Decomposition
(D) Denitrification

50. Match the processes in List I with their role in the Carbon cycle in List II.
List I: Processes
P. Photosynthesis
Q. Respiration
R. Combustion of fossil fuels
S. Ocean buffering
List II: Roles
1. Releases large amounts of stored C into the atmosphere
2. Acts as a massive sink for atmospheric CO_2
3. Fixes atmospheric carbon into biomass
4. Releases CO_2 back into the atmosphere biologically
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

51. Which of the following activities does NOT return carbon dioxide to the atmosphere?
(A) Fossilization of organic matter
(B) Explosive volcanic eruptions releasing trapped gases
(C) Combustion and burning of dry woody biomass
(D) Cellular respiration occurring in terrestrial plants

52. The global oxygen cycle is most closely linked and inversely proportional to which other biogeochemical cycle?
(A) Nitrogen cycle
(B) Phosphorus cycle
(C) Carbon cycle
(D) Water cycle

53. Which vital process releases oxygen gas into the atmosphere as a byproduct?
(A) Photosynthesis
(B) Aerobic respiration
(C) Transpiration
(D) Ammonification

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54. Which phenomenon rapidly consumes atmospheric oxygen on a large scale?
(A) Atmospheric oxidation and rusting of structural metals
(B) Light-dependent photosynthetic reactions in green plants
(C) Biological nitrogen fixation by freeliving soil microbes
(D) Large-scale industrial and domestic combustion of fuels

55. The atmospheric layer that contains a specific form of oxygen (O_3) which protects the Earth from harmful UV radiation is the:
(A) Troposphere
(B) Stratosphere
(C) Mesosphere
(D) Thermosphere

56. What is the most abundant gas in the Earth's atmosphere, playing a critical role in living organisms as a component of proteins and nucleic acids?
(A) Oxygen
(B) Carbon dioxide
(C) Nitrogen
(D) Argon

57. The process of converting inert atmospheric nitrogen gas (N_2) into usable ammonia (NH_3) is called:
(A) Nitrification
(B) Denitrification
(C) Ammonification

(D) Nitrogen fixation

58. Which of the following is a symbiotic nitrogen-fixing bacterium commonly found in the root nodules of leguminous plants?
(A) Rhizobium
(B) Nitrobacter
(C) Pseudomonas
(D) Nitrosomonas

59. Consider the following statements about the nitrogen cycle:
I. Nitrogen gas cannot be utilized directly by most plants and animals.
II. Lightning can convert atmospheric nitrogen into nitrogen oxides.
III. Denitrification adds nitrate to the soil from the atmosphere.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II, and III

60. The process by which organic nitrogen from dead plants and animals is converted back into ammonia by soil microbes is known as:
(A) Denitrification
(B) Ammonification
(C) Assimilation
(D) Nitrification

61. Nitrification occurs in two main steps. First, ammonia is oxidized to nitrite by bacteria such as:
(A) Nitrosomonas
(B) Nitrobacter
(C) Rhizobium
(D) Thiobacillus

62. In the second step of nitrification, nitrite is oxidized to nitrate by which type of bacteria?
(A) Nitrosomonas
(B) Azotobacter
(C) Nitrobacter
(D) Pseudomonas

63. Plants primarily absorb nitrogen from the soil in the form of:
(A) Nitrogen gas (N_2)
(B) Nitric acid (HNO_3)
(C) Nitrogen dioxide (NO_2)
(D) Nitrates (NO_3-)

64. The reduction of nitrates in the soil back to atmospheric nitrogen gas (N_2) is termed:
(A) Nitrification
(B) Ammonification
(C) Denitrification
(D) Nitrogen fixation

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65. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Growing leguminous crops like moong or moth beans is a common agricultural practice in Rajasthan to maintain soil fertility.
Reason (R): Leguminous plants harbor bacteria that perform biological nitrogen fixation, enriching the soil with nitrogen.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

66. Which of the following bacteria are primarily responsible for the process of denitrification in the soil?
(A) Nitrosomonas and Nitrobacter
(B) Rhizobium and Azotobacter
(C) Lactobacillus and Streptococcus
(D) Pseudomonas and Thiobacillus

67. The artificial industrial process of fixing atmospheric nitrogen with hydrogen to produce ammonia for fertilizers is known as the:
(A) Haber-Bosch process
(B) Contact process
(C) Ostwald process
(D) Solvay process

68. Select the correct order of the fundamental stages of the biological nitrogen cycle.
(A) Ammonification → Nitrogen Fixation → Denitrification → Nitrification
(B) Nitrogen Fixation → Ammonification → Nitrification → Denitrification
(C) Nitrification → Denitrification → Nitrogen Fixation → Ammonification
(D) Denitrification → Ammonification → Nitrogen Fixation → Nitrification

69. The continuous circulation of water from the Earth's surface to the atmosphere and back is called the:
(A) Hydrological cycle

91. Excessive growth of algae in a water body due to nutrient pollution significantly reduces the amount of:
(A) Dissolved carbon dioxide
(B) Dissolved oxygen
(C) Heavy metals
(D) Salinity

92. A high Biochemical Oxygen Demand (BOD) in a river indicates that:
(A) The natural water body is pure and exceptionally well-oxygenated.
(B) The aquatic environment is polluted with organic matter.
(C) The body of water completely lacks essential organic nutrients.
(D) Native aquatic life is thriving without any environmental stress.

93. What is the primary role of greenhouse gases in the Earth's atmosphere?
(A) They trap outgoing infrared radiation from Earth.
(B) They reflect incoming shortwave solar radiation back into space.
(C) They effectively block harmful ultraviolet rays coming from the sun.
(D) They absorb atmospheric oxygen and continuously release carbon dioxide.

94. Which of the following is NOT a major greenhouse gas contributing to global warming?
(A) Carbon dioxide (CO_2)
(B) Methane (CH_4)
(C) Nitrogen (N_2) gas
(D) Nitrous oxide (N_2O)

95. The progressive increase in the average temperature of Earth's near-surface air and oceans is broadly termed:
(A) Ozone depletion
(B) Biomagnification
(C) Eutrophication
(D) Global warming

96. Which human activity is considered the most significant contributor to the imbalance of the global carbon cycle and subsequent global warming?
(A) The use of chemical fertilizers
(B) The construction of dams
(C) The burning of fossil fuels
(D) Mining of phosphorus rocks

97. The term 'Carbon Footprint' refers to:
(A) The total structural mass of organic carbon present within a living organism.
(B) Total greenhouse gases produced by human activity.
(C) The preserved fossilized biological remains of ancient prehistoric plants.
(D) The net annual quantity of carbon fixed by a forest ecosystem per year.

98. How does massive deforestation disrupt the carbon cycle?
(A) It significantly increases the overall rate of carbon fixation in soil layers.
(B) It causes atmospheric carbon dioxide to condense and freeze into solid dry ice.
(C) It rapidly elevates ambient oxygen concentration levels across the atmosphere.
(D) It removes a carbon sink, raising atmospheric CO_2.

99. Consider the following consequences of global warming:
I. Melting of polar ice caps and glaciers.
II. Rise in global sea levels.
III. Extreme and unpredictable weather patterns.
Which of the above statement(s) is/are correct?
(A) Only I and II
(B) Only II and III
(C) Only I
(D) I, II, and III

100. In ecological terms, what does ecosystem stability depend upon the most?
(A) Maintaining exceptionally low or minimal solar energy input.
(B) The complete ecological dominance of a single robust species.
(C) Continuous energy flow and nutrient recycling.
(D) The total biological elimination of all top predators.

101. Choose the correct statement regarding the relationship between food chain length and energy loss.
(A) Food chain length is limited by energy loss at each level.
(B) Exceptionally long food chains lose significantly less total energy overall.
(C) Natural food chains can extend infinitely because energy is constantly recycled.
(D) Short trophic food chains are inherently less efficient at transferring energy.

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(A) Carbon - Oceanic dissolved reservoirs
(B) Nitrogen - Gaseous atmospheric pool
(C) Sulphur - Atmospheric pool only
(D) Phosphorus - Crustal rock deposits

81. The phenomenon where the concentration of certain toxic chemicals increases at successive trophic levels in a food chain is known as:
(A) Bioaccumulation
(B) Biomagnification
(C) Bioremediation
(D) Eutrophication

82. For biomagnification to occur, a pollutant must possess which of the following characteristics?
(A) It must exhibit high solubility in water and undergo rapid physiological excretion.
(B) It must be rapidly degraded and broken down by native aquatic microorganisms.
(C) It must function as an abundant, naturally occurring essential organic nutrient.
(D) It must be lipid-soluble, environmentally persistent, and non-metabolized.

83. Which well-known pesticide is a classic example of a chemical that undergoes biomagnification in aquatic food chains?
(A) DDT
(B) Urea
(C) Superphosphate
(D) Malathion

84. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In an aquatic food chain, fish-eating birds at the top trophic level accumulate the highest concentration of DDT.
Reason (R): Toxic substances like DDT are neither metabolized nor excreted; instead, they are passed on to the next higher trophic level.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

85. High concentrations of DDT in birds directly interfere with the metabolism of which element, leading to thinning of eggshells and premature breaking?
(A) Calcium
(B) Iron
(C) Phosphorus
(D) Potassium

86. Minamata disease, a neurological syndrome first discovered in Japan, was caused by the biomagnification of which heavy metal in fish?
(A) Lead
(B) Arsenic
(C) Cadmium
(D) Mercury

87. In parts of Rajasthan, prolonged consumption of groundwater containing high levels of a specific mineral has led to skeletal and dental diseases. Which mineral is accumulating in the body?
(A) Iodine compounds
(B) Fluoride
(C) Copper minerals
(D) Zinc salts

88. The natural aging of a lake by nutrient enrichment of its water is called:
(A) Stratification
(B) Biomagnification
(C) Eutrophication
(D) Salinization

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89. Which two nutrients from agricultural runoff are primarily responsible for accelerated (cultural) eutrophication?
(A) Organic carbon and dissolved oxygen
(B) Sodium ions and chloride chemical compounds
(C) Elemental iron and magnesium minerals
(D) Nitrogen and phosphorus compounds

90. Match the environmental issues in List I with their primary cause in List II.
List I: Environmental Issues
P. Algal Bloom
Q. Acid Rain
R. Ozone Depletion
S. Global Warming
List II: Primary Causes
1. Chlorofluorocarbons (CFCs)
2. Excess Nitrogen and Phosphorus in water
3. Enhanced Greenhouse Effect
4. Emissions of SO_2 and NOx
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

(B) Carbon cycle
(C) Phosphorus cycle
(D) Atmospheric cycle

70. Match the key processes of the water cycle in List I with their descriptions in List II.

List I: Processes
P. Evaporation
Q. Transpiration
R. Condensation
S. Precipitation

List II: Descriptions
1. Loss of water vapor from plant leaves
2. Conversion of liquid water to vapor from water bodies
3. Falling of water back to Earth as rain or snow
4. Conversion of water vapor to liquid droplets forming clouds

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

71. The main driving forces behind the hydrological cycle are:
(A) Geothermal heat and wind
(B) Solar energy and gravity
(C) Lunar gravity and atmospheric pressure
(D) Earth's rotation and magnetism

72. Which biogeochemical cycle is notable for lacking a significant gaseous or atmospheric phase?
(A) Carbon cycle
(B) Nitrogen cycle
(C) Phosphorus cycle
(D) Oxygen cycle

73. What is the natural reservoir of phosphorus in the global ecosystem?
(A) Ocean and sea water reservoirs
(B) Gaseous atmospheric layers
(C) Polar glaciers and ice sheets
(D) Earth's crustal rock deposits

74. How does phosphorus primarily enter the ecosystem from its natural reservoir?
(A) Through weathering of rocks
(B) Through volcanic emissions
(C) Through lightning strikes
(D) Through biological respiration

75. In what specific form do plant roots generally absorb phosphorus from the soil?
(A) Elemental phosphorus
(B) Orthophosphate ions
(C) Phosphoric acid gas
(D) Phosphine gas

76. Why is phosphorus a critical element for living organisms?
(A) It serves as the primary structural component forming mammalian hemoglobin molecules.
(B) It is an essential component of cell membranes, nucleic acids, and ATP.
(C) It provides the fundamental gaseous reactant necessary for plant photosynthesis.
(D) It functions as the principal chemical agent responsible for soil nitrogen fixation.

77. Consider the following statements about the sulphur cycle:
I. Sulphur has both sedimentary and gaseous phases in its cycle.
II. In the atmosphere, sulphur is primarily present as sulphur dioxide and hydrogen sulphide.
III. Sulphur is mostly found in the Earth's crust bound in minerals like gypsum and pyrite.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II, and III

78. Which two gases, when released excessively into the atmosphere by human activities, are the primary causes of acid rain?
(A) Carbon dioxide and atmospheric methane gas
(B) Tropospheric ozone and carbon monoxide gas
(C) Sulphur dioxide and various nitrogen oxides
(D) Synthetic chlorofluorocarbons and gaseous ammonia

79. What is the major difference between the carbon cycle and the phosphorus cycle?
(A) Carbon cycles very slowly, while phosphorus cycles rapidly.
(B) Carbon is required by plants, but phosphorus is not.
(C) Carbon enters food chains through roots, while phosphorus enters through leaves.
(D) Carbon has a significant atmospheric component, whereas phosphorus does not.

80. Identify the incorrect pair regarding elements and their primary cycle reservoir.

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102. What is the fundamental difference between energy flow and matter (nutrient) flow in an ecosystem?
(A) Energy flows in a cycle, whereas matter flows one way.
(B) Both energy and matter flow in a one-way path.
(C) Both energy and matter are completely recycled.
(D) Energy flows one way, whereas matter flows in a cycle.

103. Which is the most effective measure to conserve biogeochemical cycles and restore ecosystem balance?
(A) Rapidly increasing global industrial reliance on non-renewable fossil fuels.
(B) Afforestation and sustainable agriculture.
(C) Continuously discharging raw untreated urban sewage directly into natural rivers.
(D) Systematically replacing natural forests with extensive concrete infrastructure.

104. Which biogeochemical cycle is directly disrupted by the over-application of synthetic fertilizers (like NPK) in agriculture?
(A) Atmospheric oxygen cycle and global carbon cycle
(B) Sedimentary sulphur cycle and hydrological water cycle
(C) Nitrogen and phosphorus cycles
(D) Global oxygen cycle and hydrological water cycle

105. Wetlands play a crucial role in maintaining ecosystem stability primarily because they act as:
(A) Major natural sources responsible for extreme greenhouse gas emissions.
(B) Arid desert-like landforms that reflect incoming shortwave solar radiation.
(C) Specific ecological sites where ecosystem energy flow is completely stopped.
(D) Natural filters trapping nutrients and pollutants.

106. Identify the correct pair representing a trace element and its corresponding cycle.
(A) Iron - Trace element cycle
(B) Carbon - Primary trace element biogeochemical cycle
(C) Nitrogen - Fundamental trace element atmospheric cycle
(D) Phosphorus - Highly volatile gaseous biogeochemical cycle

107. The accumulation of non-biodegradable pollutants like heavy metals in the food chain primarily affects:
(A) Producers the most
(B) Top carnivores the most
(C) Primary consumers the most
(D) Decomposers the most

108. Which group of organisms bridges the gap between the end of a food chain and the beginning of nutrient cycling?
(A) Herbivorous primary consumers
(B) Decomposers
(C) Top apex carnivores
(D) Photosynthetic producers

109. Which sequence correctly arranges the events of cultural eutrophication?
1. Fish mortality due to suffocation.
2. Algal bloom covers the water surface.
3. High nutrient influx (N & P) into the lake.
4. Depletion of dissolved oxygen.
(A) $3 \rightarrow 2 \rightarrow 4 \rightarrow 1$
(B) $2 \rightarrow 3 \rightarrow 1 \rightarrow 4$
(C) $3 \rightarrow 4 \rightarrow 2 \rightarrow 1$
(D) $4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

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110. The concept that biological systems endure and remain relatively constant over time despite environmental changes is known as:
(A) Progressive ecological succession
(B) Biological biomagnification
(C) Ecosystem homeostasis
(D) Population carrying capacity

111. Which organism is known as the "farmer's friend" because it helps in the breakdown of complex organic matter and loosening the soil, thus aiding nutrient cycling?
(A) Grasshopper
(B) Honeybee
(C) Aphid
(D) Earthworm

112. The specific area of the biosphere where living organisms interact with their non-living environment is termed an:
(A) Ecotone
(B) Ecosphere
(C) Ecosystem
(D) Ecotype

metabolic heat. Respiratory processes, biological work, movement, and physiological maintenance consume energy, leaving only a fraction of stored chemical energy available in biomass for uptake by organisms in the next level.

11. (B) Raymond Lindeman
Raymond Lindeman introduced the foundational concept known as the Ten Percent Law of energy transfer in ecological systems. His pioneering ecological research demonstrated that energy transfers between consecutive trophic levels are inherently inefficient, with approximately ten percent of chemical energy being incorporated into biomass while ninety percent dissipates during metabolic activity.

12. (B) 10 percent
The Ten Percent Law dictates that approximately ten percent of the energy available at a given trophic level is successfully converted into biomass and passed on to the subsequent higher trophic level. The remaining ninety percent is expended through cellular respiration, bodily movement, excretion, and metabolic heat loss into the environment.

13. (B) 100 Joules
Solar energy captured by primary producers undergoes sequential transfer loss across trophic levels. When grass captures ten thousand Joules of energy, primary consumers like grasshoppers receive ten percent, equal to one thousand Joules. Secondary consumers, such as frogs consuming grasshoppers, receive ten percent of that amount, leaving exactly one hundred Joules.

14. (C) Energy loss at each step leaves insufficient energy for higher levels.
Natural food chains rarely exceed three or four trophic levels due to massive energy dissipation at each step. Because approximately ninety percent of available energy is lost as metabolic heat during transfer, the total amount of usable energy rapidly diminishes, leaving insufficient biomass to support viable populations of higher-level apex predators.

15. (A) Only I
Energy flow through an ecosystem is strictly unidirectional, moving from solar radiation through producers to consumers without returning. Decomposers perform an essential role by recycling inorganic nutrients back into soil. Energy transfer is inefficient, with only about ten percent transferring between levels, while ninety percent dissipates as metabolic respiration heat.

16. (C) Ecological efficiency
Ecological efficiency refers to the percentage of energy transferred from one trophic level to the next within an ecological food chain. It measures the net effectiveness with which biological energy is captured, converted into biomass, and stored across sequential trophic steps, providing insights into the overall structural productivity of ecosystems.

17. (B) Producers
Primary producers consistently possess the maximum total quantity of energy in any standard, balanced ecosystem. As autotrophs directly capture radiant energy from the sun during photosynthesis, they form the energetic base of the ecological pyramid. Subsequent consumer levels contain progressively less energy due to continual metabolic loss at each transfer stage.

18. (D) Sun → Producer → Herbivore → Carnivore
Energy flow in terrestrial ecosystems strictly follows an ordered sequence starting from the Sun. Primary producers capture radiant solar energy to synthesize biomass through photosynthesis. Herbivorous primary consumers feed on producers to obtain stored energy, and carnivorous secondary consumers subsequently ingest herbivores, facilitating the directional movement of energy through the biological food chain.

19. (A) Energy decreases at each successive trophic level.
An upright pyramid of energy illustrates that total energy content systematically decreases at each successive trophic level from base to apex. Because metabolic processes dissipate roughly ninety percent of available energy as heat during each ecological transition, higher trophic levels invariably retain significantly less energy than the underlying producer foundation.

20. (A) P-2, Q-4, R-3, S-1
Ecological pyramids exhibit structural variations based on measured parameters. Pyramids of energy are universally upright across all ecosystems due to heat loss. Forest biomass pyramids are upright because tree mass exceeds

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ANSWERS

1. (B) Solar energy
Solar energy serves as the primary and indispensable source of energy for virtually all terrestrial and aquatic ecosystems on Earth. Autotrophic organisms, such as green plants and photosynthetic algae, capture radiant energy from sunlight to synthesize complex organic compounds through photosynthesis. This trapped energy is subsequently transferred through various higher trophic levels.

2. (D) It is unidirectional and non-cyclic.
Energy flow through an ecosystem is strictly unidirectional and non-cyclic. Radiant solar energy enters the ecosystem via primary producers during photosynthesis and moves progressively through herbivores and carnivores. At each metabolic step, energy is dissipated into the surroundings as heat, preventing it from ever returning to solar radiation or cycling backwards.

3. (A) Less than 50 percent
Out of the total incident solar radiation reaching the surface of Earth, less than fifty percent is Photosynthetically Active Radiation. This specific spectral range, spanning wavelengths between four hundred and seven hundred nanometers, represents the solar radiation capable of being absorbed by plant pigments to drive the chemical processes of photosynthesis.

4. (C) 2 to 10 percent
Plants and photosynthetic organisms absorb only a small fraction of the incoming solar radiation for primary production. Specifically, autotrophs capture only two to ten percent of the Photosynthetically Active Radiation, which corresponds to roughly one to five percent of total incident solar energy, to synthesize biomass and sustain natural terrestrial ecosystems.

5. (A) Laws of Thermodynamics
Energy dynamics within biological ecosystems strictly follow the fundamental Laws of Thermodynamics. The First Law accounts for the conservation and transformation of absorbed solar energy into chemical bond energy. The Second Law dictates that energy transfers are never completely efficient, resulting in continuous entropy increases and dissipate energy loss as unrecoverable heat.

6. (D) Producers
Producers constitute the foundational biological level of an ecosystem by producing their own organic food. Autotrophic organisms, including chlorophyll-containing vascular plants, phytoplankton, and photosynthetic bacteria, utilize radiant sunlight, water, and atmospheric carbon dioxide to construct carbon-rich organic compounds, sustaining themselves and providing chemical energy to all heterotrophic organisms.

7. (B) Trophic level
A trophic level defines the specific position an organism occupies in a functional food chain based on its primary nutritional source. Primary producers occupy the first level, followed by primary consumers, secondary consumers, and apex predators. Each subsequent level reflects a distinct step in the sequential transfer of energy through the biological ecosystem.

8. (A) P-3, Q-1, R-4, S-2
Ecosystems arrange organisms hierarchically according to nutritional habits. Green plants operate as primary producers at the first trophic level. Herbivorous grasshoppers feed directly on plants at the second trophic level. Insectivorous frogs act as primary carnivores at the third trophic level, while predatory eagles sit as top carnivores at the fourth level.

NODIA

9. (D) Zooplankton
Zooplankton are microscopic heterotrophic aquatic organisms that consume phytoplankton and organic debris, classifying them as primary consumers rather than producers. Aquatic producers consist of autotrophic organisms, such as floating phytoplankton, various algae species, and rooted or submerged aquatic plants, all of which generate organic material directly through sunlight-driven photosynthesis.

10. (A) Heat
As energy transfers sequentially between consecutive trophic levels in a food chain, a major proportion is lost into the environment as

113. Match the specific bacteria in List I with their function in the nitrogen cycle in List II.

List I: Bacteria

P. Rhizobium
Q. Nitrosomonas
R. Nitrobacter
S. Pseudomonas

List II: Functions

1. Converts Nitrite to Nitrate
2. Reduces Nitrate to Nitrogen gas
3. Converts Nitrogen gas to Ammonia
4. Converts Ammonia to Nitrite

(A) P-3, Q-4, R-1, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

114. Why is the water cycle critical for all other biogeochemical cycles?

(A) Atmospheric water directly synthesizes carbon dioxide gas during solar evaporation.
(B) Ambient water vapor permanently locks and traps persistent heavy metals in air.
(C) Soil water serves as the exclusive chemical source of elemental nitrogen for plants.
(D) Water dissolves and transports nutrients through ecosystems.

115. In an aquatic ecosystem, if the concentration of a persistent toxin is 0.003 parts per billion (ppb) in water, it can reach up to 25 parts per million (ppm) in fish-eating birds. This immense increase is an example of:

(A) Biomagnification
(B) Ecological bio-dilution process
(C) Biological bio-reduction mechanism
(D) Cultural aquatic eutrophication

116. Which of the following is NOT an effect of an imbalance in the carbon cycle?

(A) Progressive atmospheric global warming
(B) Severe aquatic ocean acidification
(C) Ozone layer depletion
(D) Unpredictable global climate change

117. What is the ecological consequence if decomposers are entirely removed from an ecosystem?

(A) Nutrient recycling stops, causing dead matter accumulation.
(B) Unidirectional ecosystem energy flow would rapidly and suddenly increase.
(C) Herbivorous primary consumers would immediately adapt and become producers.
(D) Trophic food chain structures in the biome would become significantly longer.

118. Which tree species, widely found in the arid regions of Rajasthan, plays a crucial role as a primary producer and contributes significantly to soil nutrient enrichment?

(A) Teak tree
(B) Sal tree
(C) Banyan tree
(D) Khejri tree

119. A plant process that moves water from the soil, through the roots and leaves, into the atmosphere is called:

(A) Evaporation
(B) Transpiration
(C) Precipitation
(D) Percolation

120. Which of the following correctly summarizes the "Greenhouse Effect"?

(A) Widespread cooling of the Earth's lower surface resulting from continuous cloud cover.
(B) Direct reflection of incoming solar sunlight back into space by polar ice caps.
(C) Atmospheric warming caused by trapped surface heat radiation.
(D) Commercial cultivation of horticultural crops in specialized structural glass houses.

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consumer mass. Marine biomass pyramids are inverted due to rapid phytoplankton turnover, whereas grassland number pyramids typically display upright structures.

21. (A) Human
Humans exhibit omnivorous dietary habits, allowing them to occupy multiple trophic positions depending on consumed food sources. When consuming plant-based foods directly, humans function as primary consumers at the second trophic level. When consuming herbivorous animal products, such as beef or poultry, humans act as secondary consumers operating at higher trophic levels.

22. (D) It is lost as heat during metabolic respiration.
Unabsorbed energy that fails to transfer to the subsequent trophic level is released into the surrounding environment as heat. Biological metabolic processes, such as cellular respiration, muscle contraction, temperature regulation, and active movement, dissipate stored chemical bond energy into unrecoverable thermal energy according to second law of thermodynamics principles.

23. (B) Energy is recycled by decomposers back to producers.
Matter continuously cycles through ecosystems via decomposers, but energy follows an irreversible one-way pathway. Photosynthetic producers capture radiant solar energy, which moves through consumers and decomposers before dissipating into space as thermal heat. Decomposers recycle mineral nutrients back into soil systems, but they cannot recycle dissipated thermal energy back to producers.

24. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
The pyramid of energy remains upright across every biological ecosystem without exception. This permanent structure occurs because energy transfers between trophic levels incur significant energy loss as thermal heat during metabolic respiration. Consequently, available energy strictly decreases with each upward step, validating both statements and establishing their correct logical link.

25. (D) Gross Primary Productivity
Gross Primary Productivity represents the total rate at which photosynthetic producers capture solar energy and synthesize organic matter within a specific timeframe. This total biological calculation encompasses all fixed organic material, including the fraction subsequently oxidized and consumed by plants during cellular respiration to support their physiological metabolic needs.

26. (A) NPP = GPP - Respiration
Net Primary Productivity is calculated by subtracting autotrophic respiratory losses from Gross Primary Productivity. Gross Primary Productivity measures the total chemical energy synthesized through plant photosynthesis, whereas respiratory losses account for energy consumed by plants for survival. The remaining value represents the net organic biomass available to heterotrophic consumers.

27. (B) Respiration losses
In the primary productivity relationship where Net Primary Productivity equals Gross Primary Productivity minus R, the symbol R denotes autotrophic respiration losses. Plants consume a significant portion of synthesized photosynthetic energy through internal cellular respiration, and subtracting these metabolic maintenance losses yields the net biomass accumulated within the ecosystem.

28. (B) Secondary Productivity
Secondary productivity represents the rate at which heterotrophic consumers, including herbivores, carnivores, and decomposers, synthesize new organic biomass over time. Unlike primary productivity driven by autotrophic photosynthesis, secondary productivity relies entirely on assimilated organic carbon obtained through consuming pre-existing plant or animal tissues within the ecological food web.

29. (A) Tropical rain forest
Tropical rain forests exhibit the highest annual net primary productivity among terrestrial ecosystems. Optimal environmental conditions, including abundant year-round sunlight, warm ambient temperatures, high rainfall, and dense multi-layered vegetation, maximize photosynthetic rates, resulting in rapid accumulation of organic plant biomass compared to water-limited or temperature-restricted biomes.

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111. (D) Earthworm
Earthworms are known as the farmer's friend due to their essential role in soil ecology. As burrowing detritivores, earthworms digest complex organic matter and excrete nutrient-rich casts, increasing soil nitrogen and phosphorus availability. Their continuous burrowing loosens and aerates soil, enhancing water infiltration and plant root growth.

112. (C) Ecosystem
An ecosystem defines a structural and functional unit of the biosphere where living organisms interact continuously with each other and with their non-living physical environment. Ecosystems encompass biotic components like plants, animals, and microbes, alongside abiotic factors like sunlight, air, water, and soil, operating through linked energy and nutrient pathways.

113. (A) P-3, Q-4, R-1, S-2
Specific bacteria drive key nitrogen cycle reactions. Symbiotic Rhizobium fixes atmospheric nitrogen gas into ammonia. Nitrosomonas oxidizes toxic ammonia into nitrites, while Nitrobacter oxidizes nitrites into plant-absorbable nitrates. Finally, anaerobic Pseudomonas converts soil nitrates back into free nitrogen gas through denitrification, maintaining global nitrogen balance.

114. (D) Water dissolves and transports nutrients through ecosystems.
The water cycle is fundamental to all other biogeochemical cycles because water serves as the universal solvent and medium for nutrient transport. Solvent water dissolves essential mineral ions in soil, enabling plant roots to absorb nutrients and circulating elements through aquatic environments, sediments, and living organisms across global ecosystems.

115. (A) Biomagnification
The vast increase in toxin concentration from very low levels in water to high levels in fish-eating birds illustrates biomagnification. Non-biodegradable, lipid-soluble pollutants resist excretion and accumulate in organisms, concentrating at each progressive trophic level to reach dangerous levels in apex carnivores at the top of aquatic food chains.

116. (C) Ozone layer depletion
Depletion of the stratospheric ozone layer is caused by chlorine and bromine radicals released from chlorofluorocarbons, rather than imbalances in the carbon cycle. Imbalances in carbon cycling cause global warming, ocean acidification, and altered weather patterns through elevated atmospheric carbon dioxide levels, making ozone depletion an unrelated environmental phenomenon.

117. (A) Nutrient recycling stops, causing dead matter accumulation.
Completely eliminating decomposers from an ecosystem would halt the breakdown of organic waste and dead organisms. Without saprophytic bacteria and fungi converting organic nitrogen, phosphorus, and carbon back into inorganic forms, essential soil nutrients would become locked in accumulated debris, preventing plant absorption and causing ecosystem collapse.

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118. (D) Khejri tree
Prosopis cineraria, locally known as the Khejri tree, is a vital primary producer in the arid ecosystem of Rajasthan. Its deep taproot system accesses subterranean water, while its nitrogen-fixing root nodules enrich desert soil fertility. Khejri foliage provides essential fodder and shade, supporting local wildlife and livestock survival.

119. (B) Transpiration
Transpiration is the biological process by which moisture moves through plants from roots to small pores on the underside of leaves, where it changes to vapor and releases into the atmosphere. This process creates negative tension that pulls water and dissolved mineral nutrients upward through plant xylem tissues.

120. (C) Atmospheric warming caused by trapped surface heat radiation.
The greenhouse effect refers to the natural atmospheric warming process resulting from trapped heat radiation. Earth's surface absorbs shortwave solar radiation and re-emits longwave infrared energy, which greenhouse gases like carbon dioxide and methane absorb and re-radiate back toward Earth, maintaining global temperatures suitable for sustaining living ecosystems.

base. Herbivorous grasshoppers consume grass as primary consumers. Insectivorous frogs eat grasshoppers as secondary consumers, snakes prey on frogs as tertiary consumers, and apex hawks consume snakes.

41. (D) Phosphorus cycle
The phosphorus cycle represents a classic sedimentary biogeochemical cycle because its principal environmental reservoir exists within rock formations and ocean sediments in Earth's crust. Lacking a significant volatile atmospheric phase, phosphorus enters ecosystems through rock weathering, absorbed by plants as phosphate, and returns to soil and sediment through decomposition.

42. (A) Carbon cycle
The carbon cycle is an exemplary gaseous biogeochemical cycle characterized by a prominent atmospheric reservoir pool. Carbon dioxide gas present in the atmosphere is absorbed by plants during photosynthesis and returned through cellular respiration, combustion, and decay, circulating rapidly between terrestrial biosphere, ocean surfaces, and global atmospheric boundaries.

43. (B) Standing state
The standing state refers to the total quantity of inorganic nutrients, such as carbon, nitrogen, phosphorus, and calcium, present in the soil or abiotic environment of an ecosystem at any given time. It fluctuates seasonally based on vegetation uptake rates, weathering, organic decomposition, and local environmental soil conditions.

44. (B) Nutrient movement is completely independent of soil moisture and pH.
Nutrient cycling within ecosystems depends heavily on soil parameters, including moisture levels, temperature, and soil pH. These abiotic conditions directly regulate microbial decomposition rates, chemical solubility, root absorption capacities, and mineral weathering processes. Stating that nutrient movement is independent of soil moisture and pH represents an incorrect scientific statement.

45. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Matter is continuously conserved and recycled through biogeochemical processes, whereas energy flows unidirectionally through ecosystems and dissipates as heat. Microbial decomposers convert organic debris into inorganic nutrients for plant uptake, while energetic transfers release thermal heat during respiration, validating both statements and their direct logical relationship.

46. (C) Oceans
Earth's oceans represent the largest operational global reservoir of carbon. Oceans contain approximately seventy-one percent of all global carbon, stored predominantly as dissolved inorganic carbonate and bicarbonate ions. This immense oceanic pool actively regulates atmospheric carbon dioxide levels through continuous physicochemical gas exchanges across air-water surface boundaries worldwide.

47. (D) 71 percent
Approximately seventy-one percent of total global carbon resides dissolved within world oceans in inorganic forms, including bicarbonate and carbonate ions. This massive oceanic reservoir serves as a major climate buffer, regulating atmospheric carbon dioxide concentrations by continuously absorbing and releasing carbon through air-sea gas exchange and marine biological processes.

48. (A) 1 percent
Atmospheric carbon dioxide accounts for roughly one percent of Earth's total global carbon pool. Despite its small relative percentage, atmospheric carbon dioxide plays an exceptionally critical role in driving photosynthesis, maintaining global temperature equilibrium via the greenhouse effect, and facilitating active carbon exchange among terrestrial and aquatic biomes.

49. (B) Photosynthesis
Photosynthesis is the primary biological process that removes carbon dioxide from the atmosphere and incorporates it into organic molecules. Chlorophyll-containing organisms utilize solar energy to convert inorganic carbon dioxide and water into glucose and oxygen, constructing the organic carbon base that fuels virtually all heterotrophic organisms across world ecosystems.

50. (A) P-3, Q-4, R-1, S-2
Various ecological processes regulate the global carbon cycle. Photosynthesis converts atmospheric carbon dioxide into organic biomass. Respiration releases carbon dioxide back into the air biologically. Fossil fuel combustion rapidly

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71. (B) Solar energy and gravity
Solar energy and gravity serve as the main physical forces driving the hydrological cycle. Solar radiation provides thermal energy to evaporate liquid water from surface bodies and fuel plant transpiration. Gravity subsequently drives precipitation down to Earth and pulls surface water and groundwater down toward world ocean basins.

72. (C) Phosphorus cycle
The phosphorus cycle is distinctive among major biogeochemical cycles because it lacks a significant gaseous or atmospheric component under normal environmental conditions. Phosphorus exists almost exclusively in solid mineral compounds, cycling locally through soil, rock formations, water bodies, and living organismal biomass without entering atmospheric gas exchange pathways.

73. (D) Earth's crustal rock deposits
The principal natural reservoir of phosphorus in ecosystems is Earth's crust, where it exists locked within insoluble mineral deposits, primarily apatite and phosphate rocks. Geological uplifting and chemical weathering processes slowly break down these crustal rock deposits, releasing soluble inorganic phosphate ions into soil and aquatic environments.

74. (A) Through weathering of rocks
Phosphorus enters natural ecosystems primarily through the slow chemical and physical weathering of phosphate-containing rocks in Earth's crust. Rainwater, natural acids, and mechanical weathering break down rock minerals, releasing soluble orthophosphate ions into soil moisture and surface waters, where plant roots readily absorb them for biological growth.

75. (B) Orthophosphate ions
Plant root systems absorb phosphorus from soil water almost exclusively in inorganic orthophosphate forms, specifically H_2PO_4- and $HPO_4$2- ions. Soil pH directly determines the abundance of these specific ionic species, which plants absorb through active transport across root membranes to drive essential energetic and structural biological pathways.

76. (B) It is an essential component of cell membranes, nucleic acids, and ATP.
Phosphorus is an essential element for all living organisms because it forms structural phospholipid bilayers of cell membranes, constructs sugar-phosphate backbones of DNA and RNA, and forms high-energy phosphate bonds in ATP, making it indispensable for cellular structural integrity, genetic coding, and cellular energy transfer.

77. (D) I, II, and III
The sulphur cycle incorporates both sedimentary and gaseous phases. Crustal rocks contain abundant bound sulphur in minerals like gypsum and pyrite. Volcanoes and industrial activities release gaseous sulphur dioxide and hydrogen sulphide into the atmosphere, where atmospheric oxidation processes transform them, confirming the validity of all three statements.

78. (C) Sulphur dioxide and various nitrogen oxides
Acid rain is caused primarily by atmospheric emissions of sulphur dioxide and nitrogen oxides generated by fossil fuel combustion and industrial activity. In the atmosphere, these gases react with water vapor, oxygen, and oxidants to form sulphuric and nitric acids, which fall as acidic precipitation, damaging forests, soils, and aquatic ecosystems.

79. (D) Carbon has a significant atmospheric component, whereas phosphorus does not.
A fundamental difference between carbon and phosphorus cycles lies in their atmospheric dynamics. The carbon cycle features a massive atmospheric gaseous reservoir as carbon dioxide, facilitating global air circulation exchange. Conversely, the phosphorus cycle lacks a significant atmospheric phase, circulating strictly through rock, soil, aquatic sediments, and biological organisms.

80. (C) Sulphur - Atmospheric pool only
Pairing sulphur solely with an atmospheric pool represents an incorrect combination. The global sulphur cycle features both sedimentary and gaseous phases, maintaining its largest natural reservoir within crustal rocks and evaporite sediments as sulphate minerals, alongside its atmospheric presence as sulphur dioxide and hydrogen sulphide gases.

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organic nitrogen compounds like proteins and nucleic acids into simpler inorganic ammonia compounds, returning accessible nitrogen to soil environments.

61. (A) Nitrosomonas
Nitrification represents a two-step aerobic process mediated by chemoautotrophic soil bacteria. In the initial step, specialized nitrifying bacteria such as Nitrosomonas oxidize toxic ammonia into nitrite ions. This biological oxidation produces energy for bacterial metabolism while preparing nitrogen compounds for subsequent oxidation into plant-absorbable nitrate forms.

62. (C) Nitrobacter
During the second distinct stage of soil nitrification, specialized chemoautotrophic bacteria known as Nitrobacter oxidize nitrite ions into nitrate ions. This aerobic biological oxidation converts toxic intermediate nitrites into stable nitrates, which represent the primary, highly soluble form of nitrogen absorbed by plant root systems.

63. (D) Nitrates (NO_3-)
Vascular plants absorb nitrogen from soil moisture predominantly in the form of nitrate ions. Although plants can assimilate some ammonium ions, nitrates are highly soluble in soil water and readily absorbed by root systems via active transport, moving into plant tissues to synthesize essential amino acids and proteins.

64. (C) Denitrification
Denitrification is the biochemical process in which specialized anaerobic bacteria reduce soil nitrates and nitrites into gaseous nitrogen compounds, primarily molecular nitrogen gas. This process typically occurs in waterlogged or oxygen-depleted soils, returning fixed soil nitrogen back into atmospheric circulation and completing the global nitrogen cycle.

65. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Cultivating leguminous crops like moong or moth beans is a widespread agricultural practice in Rajasthan designed to restore soil fertility naturally. Root nodules of leguminous plants harbor symbiotic Rhizobium bacteria that fix atmospheric nitrogen into bioavailable forms, enriching soil nitrogen levels and validating both statements and their direct logical relationship.

66. (D) Pseudomonas and Thiobacillus
Anaerobic bacteria such as Pseudomonas and Thiobacillus drive soil denitrification. In oxygen-deficient environments like submerged or compacted soils, these facultative anaerobes utilize nitrate ions as terminal electron acceptors for cellular respiration, converting nitrates back into free atmospheric nitrogen gas and closing the global nitrogen cycle.

67. (A) Haber-Bosch process
The Haber-Bosch process is an industrial chemical procedure that synthesizes ammonia by reacting atmospheric nitrogen gas with hydrogen gas under high pressures and elevated temperatures in the presence of an iron catalyst. This process generates massive quantities of synthetic nitrogenous fertilizers, fundamentally altering global agricultural productivity.

68. (B) Nitrogen Fixation → Ammonification → Nitrification → Denitrification
The biological nitrogen cycle follows a defined operational sequence. Nitrogen fixation first converts atmospheric nitrogen into bioavailable ammonia. Organisms assimilate nitrogen, and post-mortem ammonification breaks down organic debris into ammonia. Nitrification subsequently oxidizes ammonia into nitrites and nitrates, which denitrification eventually reduces back into atmospheric nitrogen gas.

69. (A) Hydrological cycle
The hydrological cycle represents the continuous movement of water among Earth's atmosphere, land surface, oceans, and living organisms. Driven by solar radiation and gravity, water undergoes evaporation, transpiration, atmospheric condensation, precipitation, and groundwater runoff, ensuring perpetual distribution and purification of Earth's fresh water resources.

70. (A) P-2, Q-1, R-4, S-3
The hydrological cycle involves key physical processes. Evaporation converts surface water into atmospheric vapor. Transpiration releases water vapor through plant stomata. Condensation cools atmospheric vapor into clouds and water droplets, while precipitation returns liquid or frozen water back to Earth's surface as rain, sleet, or snow.

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30. (A) P-3, Q-1, R-4, S-2
Ecosystems display varying productivity levels dictated by local environmental factors. Arid deserts exhibit very low productivity due to extreme water scarcity. Coral reefs foster exceptionally high productivity driven by efficient nutrient recycling. Open oceans display low unit-area productivity despite large total area, while coastal estuaries achieve high productivity levels.

31. (D) Water
In the arid and semi-arid regions of Rajasthan, water availability serves as the primary limiting factor restricting net primary productivity. High temperatures and intense sunlight provide abundant light energy, but severe moisture deficits limit plant transpiration, stomatal opening, nutrient absorption, and overall photosynthetic synthesis across desert plant communities.

32. (C) Standing crop
The standing crop represents the total mass of living biological material present within a specific trophic level, ecosystem, or defined area at a given point in time. It is measured either as total organism numbers or as total biomass, providing a static snapshot of stored biological energy within living tissues.

33. (B) Dry weight
Expressing biomass in terms of dry weight provides the most accurate measure of organic matter content in ecological studies. Fresh weight varies considerably due to fluctuating organismal water retention, environmental humidity, and hydration states. Removing water content yields an objective, consistent measurement of actual stored structural carbon and chemical energy.

34. (C) 49 percent
Carbon constitutes approximately forty-nine percent of the total dry weight of living organisms, making it the second most abundant element in biomass after water. Carbon forms the fundamental structural backbone of essential biological macromolecules, including proteins, carbohydrates, lipids, and nucleic acids across all terrestrial and aquatic living organisms.

35. (C) I and III
Primary productivity depends on plant species, nutrient availability, solar radiation, and environmental conditions. Environmental factors directly regulate photosynthetic rates in autotrophs. Net Primary Productivity represents stored biomass remaining after autotrophic respiration, serving as the usable energetic resource for heterotrophic consumers across terrestrial and aquatic ecosystems.

36. (C) The movement of nutrient elements through biotic and abiotic components.
A biogeochemical cycle defines the continuous movement and exchange of essential chemical elements between living organisms and non-living environmental components. Nutrients such as carbon, nitrogen, phosphorus, and oxygen circulate through living organisms, soil, water, and atmosphere, ensuring sustainable nutrient recycling without permanent loss within global terrestrial and aquatic ecosystems.

37. (A) Gaseous and Sedimentary cycles
Biogeochemical cycles are classified into gaseous and sedimentary cycles based on primary natural reservoir locations. Gaseous cycles, including carbon, nitrogen, and oxygen, utilize atmospheric or oceanic reservoirs and circulate rapidly. Sedimentary cycles, including phosphorus and sulphur, maintain primary reservoirs within Earth's crustal rocks, moving far more slowly through weathering.

38. (D) Atmosphere or ocean
The primary reservoir pool for gaseous biogeochemical cycles is located within the atmosphere or oceans. Essential elements such as carbon, nitrogen, and oxygen cycle predominantly through gaseous compounds, allowing rapid distribution and rapid balancing of local atmospheric deficits through global wind circulation and air-sea gas exchange mechanisms.

39. (B) Earth's crust
Sedimentary nutrient cycles maintain their primary reservoir pool within Earth's crust, comprised of sedimentary rocks, soil deposits, and mineral sediments. Elements like phosphorus and calcium release gradually into ecosystems through geological weathering and erosion, circulating slowly through terrestrial and aquatic organisms before returning to sediments via precipitation and sedimentation.

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40. (A) $2 \rightarrow 5 \rightarrow 4 \rightarrow 1 \rightarrow 3$
A classic terrestrial food chain follows a precise sequence based on feeding relationships. Grass acts as the primary autotrophic producer at the

81. (B) Biomagnification
Biomagnification refers to the progressive increase in concentration of persistent, non-biodegradable toxic chemicals in tissue at higher trophic levels of a food chain. Fat-soluble pollutants accumulated by primary producers concentrate incrementally as energy transfers through herbivores to top predators, producing severe toxicity in apex carnivores.

82. (D) It must be lipid-soluble, environmentally persistent, and non-metabolized.
For a pollutant to undergo ecological biomagnification, it must exhibit high lipid solubility, strong environmental persistence, and resistance to biological metabolism or excretion. These properties allow the non-biodegradable substance to accumulate within animal adipose tissues, concentrating progressively higher at each successive trophic step along the food chain.

83. (A) DDT
Dichlorodiphenyltrichloroethane, commonly known as DDT, is a synthetic organochlorine insecticide that serves as a classic example of biomagnification. Because DDT is fat-soluble and highly persistent, low concentrations in water accumulate rapidly through plankton and small fish, reaching dangerous concentrations in fish-eating birds at top trophic levels.

84. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Fish-eating birds at the apex of aquatic food chains accumulate the highest concentrations of DDT in their bodies. This occurs because synthetic organochlorines like DDT are lipid-soluble, non-metabolized, and poorly excreted, transferring efficiently up food chains, validating both statements and establishing their correct direct explanatory connection.

85. (A) Calcium
High bioaccumulated concentrations of DDT in birds directly disrupt calcium metabolism by inhibiting enzyme calcium ATPase. This biochemical interference impairs eggshell gland functioning, causing marked thinning of eggshells and premature shell breakage during incubation, which leads to severe population declines in predatory bird species.

86. (D) Mercury
Minamata disease is a severe neurological syndrome first identified in Japan, caused by consumption of fish contaminated with methylmercury. Industrial wastewater discharges released inorganic mercury into Minamata Bay, where aquatic microbes converted it to organic methylmercury, which biomagnified up marine food chains into human food supplies.

87. (B) Fluoride
Chronic consumption of groundwater containing high levels of dissolved fluoride in several arid districts of Rajasthan causes severe endemic fluorosis. Excess ingested fluoride accumulates progressively in calcified human tissues, leading to widespread dental fluorosis, skeletal deformities, joint stiffness, and chronic bone damage across affected rural populations.

88. (C) Eutrophication
Eutrophication defines the natural or accelerated aging of an aquatic ecosystem resulting from nutrient enrichment. Nutrient loading stimulates excessive primary productivity, inducing massive algal blooms. Subsequent microbial decomposition of decaying plant material consumes dissolved oxygen, causing severe hypoxia, fish kills, and progressive deterioration of water body quality.

89. (D) Nitrogen and phosphorus compounds
Cultural eutrophication of aquatic ecosystems is driven primarily by excessive runoff containing nitrogen and phosphorus compounds derived from agricultural fertilizers and untreated sewage. These limiting plant nutrients stimulate explosive growth of algae and cyanobacteria, accelerating water body eutrophication and causing widespread oxygen depletion in aquatic environments.

90. (A) P-2, Q-4, R-1, S-3
Major environmental issues stem from specific anthropogenic causes. Excess nitrogen and phosphorus runoff triggers dense aquatic algal blooms. Emissions of sulphur dioxide and nitrogen oxides cause acid rain. Chlorofluorocarbons destroy stratospheric ozone, while enhanced greenhouse gas accumulation drives progressive global warming trends across Earth.

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injects vast quantities of long-stored carbon into the atmosphere, while ocean buffering serves as a massive sink absorbing atmospheric carbon.

51. (A) Fossilization of organic matter
Fossilization sequesters carbon deep underground for geological periods rather than releasing carbon dioxide into the air. Respiration, biomass combustion, and volcanic eruptions actively vent carbon dioxide gas into atmospheric circulation. Fossilization buries organic matter under sedimentary layers, effectively removing carbon from active ecosystem cycling until extracted and burned.

52. (C) Carbon cycle
The global oxygen cycle is tightly linked and inversely proportional to the carbon cycle. Photosynthesis absorbs carbon dioxide to produce organic compounds while generating oxygen gas as a byproduct. Conversely, cellular respiration and combustion consume atmospheric oxygen to break down carbon compounds, producing carbon dioxide and completing the reciprocal cycle.

53. (A) Photosynthesis
Photosynthesis is the principal biological process that generates atmospheric oxygen gas. During light-dependent reactions within plant chloroplasts and cyanobacteria, water molecules undergo photolysis, splitting into hydrogen ions, electrons, and molecular oxygen gas. This continuously released oxygen replenishes the atmosphere, supporting aerobic life across the planet.

54. (D) Large-scale industrial and domestic combustion of fuels
Large-scale combustion of fossil fuels and organic matter rapidly consumes substantial quantities of atmospheric oxygen. Burning coal, petroleum, natural gas, and wood involves chemical oxidation reactions that consume free oxygen gas to yield carbon dioxide, water vapor, and thermal energy, significantly driving global atmospheric gas exchanges.

55. (B) Stratosphere
The stratosphere contains the ozone layer, composed of triatomic oxygen molecules situated between fifteen and thirty kilometers above Earth's surface. This stratospheric ozone layer performs a vital biological protective function by absorbing harmful ultraviolet-B solar radiation, shielding living organisms on Earth from genetic mutations, skin cancers, and cellular damage.

56. (C) Nitrogen
Nitrogen is the most abundant gas in Earth's atmosphere, constituting approximately seventy-eight percent of air by volume. Although molecular nitrogen gas is chemically inert and directly unassimilable by most organisms, nitrogen represents an essential structural component required for constructing amino acids, proteins, nucleic acids, and photosynthetic chlorophyll molecules.

57. (D) Nitrogen fixation
Nitrogen fixation is the essential chemical or biological process that converts inert atmospheric nitrogen gas into reactive, biologically available compounds such as ammonia. Specialized nitrogen-fixing microorganisms, industrial processes, and high-energy atmospheric lightning strikes break the strong triple covalent bond of nitrogen gas, making nitrogen accessible to autotrophic plants.

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58. (A) Rhizobium
Rhizobium is a symbiotic, nitrogen-fixing bacterium that inhabits specialized root nodules of leguminous plants. Through a mutualistic relationship, Rhizobium utilizes enzyme nitrogenase to convert atmospheric nitrogen into ammonia, providing essential nitrogenous nutrients to the host plant while receiving carbohydrates and safe ecological shelter in return.

59. (A) I and II
Atmospheric nitrogen gas cannot be directly assimilated by higher plants and animals, requiring biological or chemical fixation. High-energy lightning provides energy to synthesize nitrogen oxides from atmospheric gases. Denitrification reduces soil nitrates back into atmospheric nitrogen gas, rather than adding nitrates to soil, rendering statement three incorrect.

60. (B) Ammonification
Ammonification is the biological process by which decomposers, including specialized saprophytic bacteria and fungi, break down nitrogenous organic wastes and dead plant or animal tissues. Microorganisms convert complex

101. (A) Food chain length is limited by energy loss at each level.
Ecological food chains are strictly limited in length due to continuous energy loss at each successive trophic transfer step. Because roughly ninety percent of available energy dissipates as metabolic heat, total usable energy diminishes rapidly, leaving insufficient biomass at higher levels to sustain viable populations of apex carnivores.

102. (D) Energy flows one way, whereas matter flows in a cycle.
The fundamental difference between energy and matter in ecosystems lies in their movement patterns. Energy flows unidirectionally from the Sun through producers and consumers before dissipating into space as unrecoverable heat. Conversely, chemical matter and nutrient elements cycle continuously between biotic organisms and abiotic environmental reservoirs.

103. (B) Afforestation and sustainable agriculture.
Practicing afforestation and sustainable agriculture represents the most effective strategy to conserve biogeochemical cycles and restore ecosystem balance. Planting trees expands carbon sinks and stabilizes local hydrological cycles, while sustainable farming practices minimize synthetic nutrient runoff, preventing eutrophication and protecting natural soil-water biogeochemical dynamics.

104. (C) Nitrogen and phosphorus cycles
Over-applying synthetic chemical fertilizers containing nitrogen, phosphorus, and potassium directly disrupts natural nitrogen and phosphorus cycles. Excess agricultural nitrates and phosphates leach into groundwater and wash into aquatic ecosystems via surface runoff, causing severe cultural eutrophication, destructive algal blooms, and oxygen depletion in water bodies.

105. (D) Natural filters trapping nutrients and pollutants.
Wetlands maintain ecosystem stability by functioning as natural biological filters. Specialized wetland vegetation and benthic sediments trap excess agricultural nutrients, heavy metals, suspended solids, and chemical pollutants from runoff. This natural filtration purifies surface water, controls flooding, recharges aquifers, and prevents severe downstream eutrophication in aquatic biomes.

106. (A) Iron - Trace element cycle
Iron represents a classic trace element whose cycling through soil and aquatic ecosystems is essential for biological function. Although required in small quantities by organisms, iron acts as a vital micronutrient cofactor in metabolic processes, including photosynthetic electron transport chains, cellular respiration cytochromes, and enzyme activation pathways.

107. (B) Top carnivores the most
Non-biodegradable pollutants like heavy metals and organochlorines accumulate most severely in top carnivores. Because these persistent fat-soluble toxins cannot be metabolized or excreted, they undergo biomagnification along food chains, concentrating incrementally at higher trophic levels and causing reproductive failure, toxicity, and high mortality in apex predators.

108. (B) Decomposers
Decomposers, including saprophytic bacteria and fungi, bridge the gap between the end of a food chain and the beginning of nutrient cycling. By breaking down complex organic compounds in dead organisms and metabolic wastes, decomposers release essential inorganic nutrients back into soil and water, enabling producers to absorb them again.

109. (A) $3 \rightarrow 2 \rightarrow 4 \rightarrow 1$
Cultural eutrophication follows a defined ecological sequence. Influxes of nitrogen and phosphorus enter a water body from agricultural runoff. These surplus nutrients trigger explosive algal blooms on the surface. Aerobic decomposition of dying algae rapidly depletes dissolved oxygen levels, causing severe aquatic hypoxia and widespread fish suffocation.

110. (C) Ecosystem homeostasis
Ecosystem homeostasis defines the intrinsic capability of an ecological system to maintain internal stability and balance over time despite external environmental disturbances. Through complex biotic interactions, nutrient cycling, and negative feedback mechanisms, ecosystems regulate species populations, productivity rates, and energetic processes to preserve long-term functional equilibrium.

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91. (B) Dissolved oxygen
Excessive algal blooms caused by aquatic nutrient pollution significantly reduce dissolved oxygen levels in water bodies. When dense algal populations die, aerobic decomposers multiply rapidly to break down organic matter. This intense microbial respiration depletes dissolved oxygen from the water, creating hypoxic dead zones and causing mass fish mortality.

92. (B) The aquatic environment is polluted with organic matter.
A high Biochemical Oxygen Demand value in a river indicates substantial organic pollution. Aerobic bacteria require large quantities of dissolved oxygen to decompose abundant organic waste present in water. Consequently, higher rates of oxygen consumption by decomposers reflect higher levels of organic pollution in the aquatic ecosystem.

93. (A) They trap outgoing infrared radiation from Earth.
Greenhouse gases play a vital thermal role in Earth's atmosphere by absorbing outgoing longwave infrared radiation emitted by Earth's surface after it absorbs shortwave solar radiation. By re-emitting trapped heat energy back toward Earth, these gases maintain global ambient surface temperatures suitable for sustaining life.

94. (C) Nitrogen (N_2) gas
Diatomic nitrogen gas makes up seventy-eight percent of the atmosphere but does not act as a greenhouse gas because its symmetric homonuclear molecular structure cannot absorb longwave infrared radiation. Major greenhouse gases contributing to global thermal warming include carbon dioxide, methane, nitrous oxide, ozone, and atmospheric water vapor.

95. (D) Global warming
Global warming refers to the ongoing rise in Earth's average surface temperatures across air and ocean systems. Driven primarily by elevated atmospheric concentrations of anthropogenic greenhouse gases from fossil fuel combustion and deforestation, global warming alters climate systems, melts glaciers, elevates sea levels, and disrupts global ecosystems.

96. (C) The burning of fossil fuels
Burning fossil fuels like coal, petroleum, and natural gas represents the most significant human activity disrupting the global carbon cycle. This combustion releases geological carbon reserves stored underground for millions of years into atmospheric circulation as carbon dioxide, intensifying the atmospheric greenhouse effect and accelerating global warming.

97. (B) Total greenhouse gases produced by human activity.
The term carbon footprint defines the total cumulative amount of greenhouse gas emissions, expressed as carbon dioxide equivalents, generated directly or indirectly by human activities, individuals, organizations, or industrial processes. Measuring carbon footprints helps evaluate environmental impacts and formulate strategies for mitigating global warming and climate change.

98. (D) It removes a carbon sink, raising atmospheric CO_2.
Massive deforestation disrupts the global carbon cycle by removing major living carbon sinks. Forests absorb vast quantities of atmospheric carbon dioxide through photosynthesis and store it as biomass. Clearing and burning trees halts carbon uptake while releasing stored carbon back into the atmosphere, elevating atmospheric greenhouse gas levels.

99. (D) I, II, and III
Global warming produces widespread ecological and physical impacts across the planet. Rising global surface temperatures cause extensive melting of polar ice caps and continental glaciers. Thermal expansion of oceans combined with melting ice elevates sea levels, while altered thermal gradients trigger extreme, unpredictable weather events worldwide.

100. (C) Continuous energy flow and nutrient recycling.
Ecosystem stability depends fundamentally on continuous energy flow and efficient nutrient recycling. A steady input of solar energy converted by producers, alongside uninterrupted recycling of inorganic nutrients by decomposers, maintains structural integrity, supports species diversity, and enables ecosystems to resist environmental disturbances through internal self-regulating feedback mechanisms.

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CHAPTER 15

Biotechnology: General Information and Patents

1. According to the European Federation of Biotechnology (EFB), biotechnology is defined as the integration of natural science and organisms, cells, parts thereof, and what else for products and services?
(A) Mechanical devices
(B) Molecular analogues
(C) Synthetic chemicals
(D) Heavy metals

2. Which of the following is considered a core principle of modern biotechnology?
(A) Classical selective plant and animal breeding techniques
(B) Large-scale industrial thermodynamic engineering
(C) Traditional mechanical extraction of cellular juices
(D) Genetic engineering and bioprocess engineering

3. The broad scope of modern biotechnology encompasses which of the following areas?
(A) Therapeutics, diagnostics, GM crops, and bioremediation
(B) Healthcare diagnostics and the production of human medicines
(C) Plant tissue culture and traditional agricultural improvements
(D) Industrial manufacturing of synthetic biodegradable plastics

4. Who among the following is commonly credited with coining the term 'Biotechnology' in 1919?
(A) Louis Pasteur
(B) Alexander Fleming
(C) Karl Ereky
(D) Gregor Mendel

5. The first recombinant DNA molecule was constructed in 1972 by linking an antibiotic resistance gene to the native plasmid of which bacterium?
(A) Salmonella typhimurium
(B) Escherichia coli
(C) Bacillus thuringiensis
(D) Agrobacterium tumefaciens

6. Match the scientists in List I with their major contributions in List II:
List I:
P. Stanley Cohen and Herbert Boyer
Q. Kary Mullis
R. Ian Wilmut
S. Alexander Fleming
List II:
1. Invention of Polymerase Chain Reaction (PCR)
2. Discovery of Penicillin
3. Creation of the first recombinant DNA molecule
4. Cloning of Dolly the sheep
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

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Which of the following is a classic example of traditional biotechnology practiced for thousands of years?
(A) Producing genetically modified insulin
(B) Making curd using lactic acid bacteria
(C) Cloning farm animals
(D) Extracting DNA using restriction enzymes

8. The foundation of modern genetic engineering was laid in 1968 by the discovery of which specific molecules?
(A) Structural cellular ribosomes
(B) Single-stranded transfer RNAs
(C) Restriction endonucleases
(D) Specific monoclonal antibodies

9. What is the fundamental difference that sets modern biotechnology apart from traditional biotechnology?
(A) Modern biotechnology relies solely on natural sunlight and raw environmental water

mixed directly into commercial livestock feed
(B) Administering oral biological therapies to treat acute bacterial food poisoning
(C) Modifying edible plants to express antigens that trigger immunity when eaten
(D) Synthesizing liquid oral vaccine formulations using concentrated sugar syrups

49. In plant tissue culture, the specific part of a plant taken out and grown in a sterile artificial medium is referred to as an?
(A) Inoculum
(B) Explant
(C) Embryoid
(D) Organelle

50. The inherent capacity of a single isolated plant cell to divide, grow, and generate a completely new, fully functioning whole plant is known as?
(A) Pluripotency
(B) Multipotency
(C) Unipotency
(D) Totipotency

51. The technique used in tissue culture to rapidly produce thousands of genetically identical plants from a small explant is known as?
(A) Micropropagation
(B) Somatic hybridization
(C) Bioremediation
(D) Biofortification

52. Match the terms related to tissue culture in List I with their descriptions in List II:
List I:
P. Callus
Q. Somaclones
R. Protoplast
S. Nutrient medium
List II:
1. Plants genetically identical to the original plant
2. An unorganized, undifferentiated mass of cells
3. A sterile mixture containing carbon sources, vitamins, and plant hormones
4. A plant cell completely devoid of its cell wall
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-2, S-1

53. Stem cells are uniquely defined by their fundamental ability to?
(A) Self-renew endlessly and differentiate into specialized cell types
(B) Synthesize and secrete highly specific protective antibodies against viral pathogens
(C) Synthesize and store massive amounts of dietary starch within cellular plastids
(D) Undergo specialized meiotic cell division rapidly and efficiently in tissue

54. Pluripotent embryonic stem cells, which have the potential to form almost any cell type in the human body, are typically derived from which stage of embryonic development?
(A) Newly formed diploid zygote
(B) Developing late-stage fetus
(C) Unfertilized mature human ovum
(D) Inner cell mass of a blastocyst

55. Adult stem cells are found in various tissues of the mature human body. Which of the following is a common source of adult stem cells used in medical therapies today?
(A) Hair shafts
(B) Bone marrow
(C) Tooth enamel
(D) Red blood cells

56. A well-established and widely practiced stem cell therapy used globally for treating certain types of leukemia and blood disorders involves the transplantation of?
(A) Central nervous system neural stem cells
(B) Basal layer epidermal stem cells
(C) Hematopoietic stem cells from bone marrow
(D) Myocardial cardiac progenitor stem cells

57. What is the fundamental definition of a patent in the context of Intellectual Property Rights?
(A) A permanent lifelong financial grant awarded by the government to an inventor for breakthroughs
(B) A strictly confidential laboratory document kept hidden by scientific researchers from competitors
(C) A natural biological defense mechanism evolved by organisms to block horizontal gene transfer
(D) An exclusive legal right granted to an inventor to exploit an invention for a set period

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(D) Plasmid Copying Routine

20. In gene cloning vectors, the specific sequence where replication starts is denoted by which term?
(A) Selectable marker gene for transformation
(B) Multiple cloning site vector region
(C) ori (origin of replication)
(D) Upstream promoter region sequence

21. Which of the following is commonly referred to as the 'molecular scissors' in biotechnology?
(A) Restriction endonucleases
(B) Template-dependent DNA polymerases
(C) Sugar-phosphate-joining DNA ligases
(D) Transcription-initiating RNA polymerases

22. Arrange the following sequence of events that occur when a restriction endonuclease acts upon a DNA molecule in the correct order:
I. Making a cut in the sugar-phosphate backbone of the DNA.
II. Inspecting the length of the DNA molecule.
III. Binding tightly to the specific recognition sequence.
IV. Finding the specific palindromic recognition sequence.
(A) II, IV, III, I
(B) I, II, III, IV
(C) IV, III, II, I
(D) II, III, I, IV

23. Most restriction endonucleases make staggered cuts in the DNA double helix, leaving short, single-stranded overhanging stretches. These overhanging stretches are called?
(A) Blunt ends
(B) Sticky ends
(C) Recessive ends
(D) Leading ends

24. Match the following enzymes in List I with their specific functions in List II:
List I:
P. Exonuclease
Q. Endonuclease
R. DNA Ligase
S. DNA Polymerase
List II:
1. Joins two DNA fragments together
2. Removes nucleotides from the ends of the DNA
3. Synthesizes a new DNA strand using a template
4. Cuts DNA at specific positions within the molecule
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-4, R-3, S-1
(D) P-4, Q-2, R-3, S-1

25. The specific sequence of DNA recognized by a restriction enzyme, which reads the same on both strands in the 5' to 3' direction, is known as a?
(A) Specific nonsense mutation sequence
(B) Eukaryotic mRNA poly-A tail region
(C) Terminal chromosome telomere sequence
(D) Palindromic nucleotide sequence

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26. In the field of medicine, biotechnology is heavily used to produce highly specific proteins that can target diseases without adverse immunological responses. These proteins are known as?
(A) Recombinant therapeutics
(B) Synthetic alkaloids
(C) Broad-spectrum antibiotics
(D) Phytochemicals

27. Gene therapy, a revolutionary medical application of biotechnology, aims to treat genetic disorders by?
(A) Performing extensive surgical procedures to extract defective diseased organs
(B) Delivering a functional gene into cells to correct a defective one
(C) Applying high doses of ionizing radiation to mutate non-functional cells
(D) Administering synthetic pharmaceutical drugs continuously over a lifetime

28. The first clinical gene therapy was administered in 1990 to a 4-year-old girl suffering from Severe Combined Immunodeficiency (SCID) caused by the deficiency of which enzyme?
(A) Template-dependent DNA polymerase
(B) Adenosine deaminase (ADA)
(C) Glycolytic enzyme hexokinase
(D) Intestinal digestive lactase

29. Which of the following was the first genetically engineered human medicine approved for commercial use?
(A) Insulin
(B) Human Growth Hormone
(C) Penicillin
(D) Aspirin

(B) Traditional biotechnology relies on industrial stainless-steel bioreactors
(C) Traditional biotechnology is restricted exclusively to domestic animals
(D) Modern biotechnology involves direct genetic manipulation of DNA or RNA

10. Consider the following statements regarding modern and traditional biotechnology:
I. Traditional biotechnology relies on the natural metabolic capabilities of organisms.
II. Modern biotechnology involves crossing natural species barriers using recombinant DNA technology.
III. Traditional biotechnology exclusively involves synthetic chemicals.
Which of the statements given above is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

11. Which of the following is purely a product of modern biotechnology?
(A) Wine produced from grapes
(B) Human insulin produced by E. coli
(C) Bread baked using yeast
(D) Compost made from agricultural waste

12. In the context of biotechnology, the 'natural genetic engineer' of plants is a title given to which bacterium?
(A) Pseudomonas putida bacterial species
(B) Agrobacterium tumefaciens
(C) Soil-dwelling Bacillus subtilis
(D) Nitrogen-fixing Rhizobium leguminosarum

13. Recombinant DNA technology can be best described as the process of?
(A) Combining foreign DNA fragments and inserting them into a host organism
(B) Enzymatically breaking down complex dietary proteins into free amino acids
(C) Culturing undifferentiated plant cells in an artificial nutrient medium
(D) Producing high-yielding hybrid crop seeds through manual cross-pollination

14. In recombinant DNA technology, which entity acts as the 'vehicle' to carry a foreign DNA fragment into a host cell?
(A) Restriction enzyme
(B) Ligase
(C) Vector
(D) Primer

15. What specific role does the enzyme DNA ligase play in recombinant DNA technology?
(A) It precisely cuts DNA strands at specific palindromic sequences
(B) It synthesizes complementary RNA molecules from a DNA template strand
(C) It unwinds and separates double-stranded genomic DNA molecules
(D) It joins sugar-phosphate backbones of two DNA fragments

16. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Plasmids are widely used as vectors in recombinant DNA technology.
Reason (R): Plasmids are extrachromosomal, circular DNA molecules that can replicate independently of the genomic DNA.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

17. The basic concept of gene cloning involves creating?
(A) Multiple identical genetic copies of an entire multicellular organism
(B) Multiple identical copies of a specific gene or DNA segment
(C) Fully functional artificial chromosomes created from synthetic chemicals
(D) Various mutant variations of a non-functional regulatory gene

18. What is the correct term for the bacterial host cell that has successfully taken up the recombinant plasmid during cloning?
(A) Competent cell
(B) Transgenic plant
(C) Cloned vector
(D) Transformed cell

19. The technique known as PCR, which revolutionized gene cloning and DNA amplification, stands for?
(A) Polymerase Chain Reaction
(B) Polypeptide Chain Recombination
(C) Primary Cloning Resource

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Assertion (A): Downstream processing is a mandatory step in industrial biotechnology.
Reason (R): It involves the separation, purification, and preservation of the desired product before it is ready for marketing.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

41. Biofertilisers are best defined as?
(A) Specialized synthetic chemical compounds used to eradicate soil pests
(B) Fast-growing genetically modified seeds requiring artificial inputs
(C) Concentrated inorganic chemical salts added to elevate soil pH levels
(D) Microorganisms that enrich the nutrient quality of soil

42. Match the following biofertilisers in List I with their defining characteristics in List II:
List I:
P. Rhizobium
Q. Azotobacter
R. Mycorrhiza
S. Azolla
List II:
1. Free-living nitrogen-fixing bacterium in soil
2. Symbiotic nitrogen-fixing bacterium in legume roots
3. Aquatic fern hosting symbiotic cyanobacteria
4. Symbiotic association of fungi with plant roots for phosphorus uptake
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-3, S-4
(D) P-4, Q-3, R-2, S-1

43. Biopesticides are preferred over traditional chemical pesticides because they?
(A) Eradicate all broad insect populations rapidly and indiscriminately
(B) Target specific pests safely without harming non-target organisms
(C) Persist toxically in agricultural soil for several decades
(D) Instantly eliminate all types of unwanted agricultural weeds

44. Consider the following statements about biofertilisers and biopesticides:
I. Trichoderma species act as effective biocontrol agents against several plant pathogens.
II. Cyanobacteria (blue-green algae) are used as biofertilisers primarily in paddy fields.
III. Urea and Superphosphate are examples of advanced biofertilisers.
Which of the statements given above is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

45. Recombinant DNA vaccines, such as the modern Hepatitis B vaccine, are generally considered safer than traditional vaccines because they?
(A) Contain purified antigen proteins without pathogenic organisms
(B) Contain live, fully active and highly virulent disease pathogens
(C) Irreversibly integrate into and alter the host human genome
(D) Completely suppress rather than stimulate host immune responses

46. Select the correct sequence of fundamental steps involved in producing a recombinant protein vaccine:
(A) Expression in host cells → Isolation of antigen gene → Insertion into a vector → Purification
(B) Isolation of antigen gene → Insertion into a vector → Expression in host cells → Purification
(C) Insertion into a vector → Purification → Expression in host cells → Isolation of antigen gene
(D) Purification → Isolation of antigen gene → Expression in host cells → Insertion into a vector

47. Which host organism is commercially utilized on a large scale to produce the recombinant Hepatitis B vaccine?
(A) Gram-negative Escherichia coli bacterium
(B) Plant-transforming Agrobacterium tumefaciens
(C) Spore-forming Bacillus subtilis bacterium
(D) Saccharomyces cerevisiae (Yeast)

48. The concept of creating 'edible vaccines' using biotechnology refers to?
(A) Formulating conventional animal vaccines

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manufacturing and marketing
(D) Safely disposing of hazardous biological waste according to safety standards

85. In the commercialisation of a biotech drug, the complex set of processes that involve separation, purification, and formulation of the final product is collectively known as?
(A) Downstream processing
(B) Upstream processing
(C) Genetic transformation
(D) Plasmid extraction

86. Arrange the following typical phases of bringing a new biotech product (like a genetically modified drug) to the market in the correct sequence:
I. Marketing and large-scale manufacturing
II. Basic Research and Development (R&D) in the lab
III. Regulatory approval from government bodies
IV. Clinical trials to ensure safety and efficacy
(A) II, IV, III, I
(B) II, III, IV, I
(C) IV, II, III, I
(D) I, II, IV, III

87. A major hurdle in the successful commercialisation of agricultural biotechnology products is?
(A) The extreme technical ease of obtaining international regulatory approvals
(B) Strict regulatory safety tests and public acceptance hurdles
(C) Complete global absence of intellectual property and patent protection laws
(D) The total physiological inability of plant cells to absorb foreign genes

88. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Extensive clinical trials are mandatory before the commercialisation of any recombinant therapeutic drug.
Reason (R): Clinical trials ensure that the drug is both safe for human consumption and effective in treating the target disease.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

89. In biotechnology, maintaining 'Biosafety' in laboratories requires the use of specialized equipment to provide a sterile working environment. Which of the following is commonly used for this purpose?
(A) High-resolution electron microscope
(B) Radiation-detecting Geiger counter
(C) Double-beam spectrophotometer
(D) Laminar air flow cabinet

90. To prevent the unintended spread of modified genes (transgenes) from GM crops to wild plant relatives via pollen, farmers and researchers are advised to?
(A) Maintain isolation distances or buffer zones around GM fields
(B) Cultivate genetically modified crop plants exclusively during nighttime hours
(C) Apply heavy concentrations of synthetic chemical herbicides on a daily basis
(D) Harvest the entire crop yield before plants begin sprouting green leaves

91. The strict ethical and safety regulations concerning human cloning globally dictate that?
(A) Anyone can clone a human with local police permission
(B) Human reproductive cloning is strictly prohibited
(C) Only therapeutic cloning is prohibited
(D) Cloning is mandatory for treating genetic diseases

92. In India, which apex regulatory committee makes decisions regarding the validity of GM research and the safety of introducing Genetically Modified Organisms (GMOs) into the environment?
(A) Indian Medical Association (IMA)
(B) Genetic Engineering Appraisal Committee (GEAC)
(C) Council of Scientific and Industrial Research (CSIR)
(D) National Green Tribunal (NGT)

93. The Genetic Engineering Appraisal Committee (GEAC) functions under the administrative control of which Union Ministry?
(A) Ministry of Environment, Forest and Climate Change
(B) Union Ministry of Health and Family Welfare
(C) Union Ministry of Agriculture and Farmers Welfare
(D) Ministry of Science and Technology, Govt of

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58. Consider the following statements regarding patents:
I. A patent prevents unauthorized parties from commercially exploiting an invention.
II. In India, a standard patent is generally valid for 50 years.
III. To be patentable, an invention must be novel, non-obvious, and have industrial applicability.
Which of the statements given above is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

59. Intellectual Property Rights (IPR) are intended to legally protect which of the following?
(A) Tangible real estate properties, commercial land plots, and physical agricultural holdings
(B) Human intellectual creations like inventions, literary works, and designs
(C) Wild floral and faunal species naturally occurring within protected national parks
(D) Fundamental mathematical formulas, abstract theories, and universal physical laws

60. Under standard Indian patent laws, which of the following scenarios is NOT eligible for a patent?
(A) A newly synthesized novel chemical compound
(B) Discovery of a natural wild plant or animal
(C) A newly invented surgical or medical device
(D) A novel genetically modified crop seed variety

61. A 'bio-patent' is specifically characterized as a patent granted by the government for?
(A) Biological materials, processes, and genetically modified organisms
(B) The design and manufacture of advanced mechanical agricultural machinery
(C) Traditional indigenous herbal remedies already established in public knowledge
(D) Advanced diagnostic medical software programs developed for clinical hospitals

62. Which historic milestone marked the first time a living organism was granted a patent in the United States?
(A) Dolly the sheep, the world's first cloned mammal produced from adult somatic cells
(B) The Flavr Savr tomato, engineered for extended shelf life and delayed ripening
(C) An oil-eating Pseudomonas bacterium developed by Ananda Chakrabarty
(D) The original scientific discovery and isolation of the Penicillium antibiotic fungus

63. Bio-patents play a crucial role in the biotechnology industry primarily by?
(A) Restricting basic scientific research across academic institutions worldwide
(B) Mandating that essential life-saving medicines be distributed free of charge
(C) Banning the agricultural cultivation of all traditional non-GM crops
(D) Safeguarding private investments and driving technological innovation

64. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The granting of bio-patents on seeds has raised ethical and socio-economic concerns globally.
Reason (R): Bio-patents provide monopolies to large corporations, potentially forcing small farmers to buy expensive new seeds every season.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

65. The international organization primarily responsible for promoting the protection of intellectual property globally is known as?
(A) WHO (World Health Organization)
(B) WIPO (World Intellectual Property Organization)
(C) UNEP (United Nations Environment Programme)
(D) FAO (Food and Agriculture Organization)

66. Intellectual Property Rights encompass several different forms. Which of the following is specifically used to protect original literary, dramatic, musical, and artistic works?
(A) Patent
(B) Trademark
(C) Geographical Indication
(D) Copyright

67. Geographical Indications (GI) are a category of intellectual property that protect products?

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(A) Originating from a specific region and having distinct qualities from that origin
(B) Scientifically engineered and invented within a certified specialized research laboratory
(C) Manufactured using completely synthetic inorganic materials without natural ingredients
(D) Commercialized and distributed exclusively on international digital e-commerce markets

68. The term 'Biopiracy' specifically refers to the practice where?
(A) Openly sharing scientific genomic data and research findings across global internet databases
(B) Traditional farmers exchanging local crop seeds among neighboring agricultural communities
(C) Exploiting bio-resources and traditional knowledge without authorization or compensation
(D) National governments enforcing strict legal bans on importing non-native biological materials

69. A classic example of biopiracy involving India was the controversial attempt by a US-based company to patent which distinct, long-grained aromatic crop?
(A) Basmati Rice
(B) Sharbati Wheat
(C) BT Cotton
(D) Golden Rice

70. Select the correct logical sequence of events that typically characterizes an act of biopiracy:
(A) Commercial exploitation → Identification of indigenous knowledge → Collection of bio-resources → Unauthorized patenting
(B) Identification of indigenous knowledge → Collection of bio-resources → Unauthorized patenting → Commercial exploitation
(C) Unauthorized patenting → Commercial exploitation → Collection of bio-resources → Identification of indigenous knowledge
(D) Collection of bio-resources → Commercial exploitation → Unauthorized patenting → Identification of indigenous knowledge

71. Which prominent Indian scientific organization successfully fought legal battles to revoke foreign patents wrongfully granted on the medicinal properties of Neem and Turmeric?
(A) Indian Space Research Organisation (ISRO)
(B) Council of Scientific and Industrial Research (CSIR)
(C) Defence Research and Development Organisation (DRDO), India
(D) National Medical Council of India (NMCI)

72. The controversy surrounding the patenting of Turmeric (Haldi) in the USA was based on its traditional Indian use primarily for?
(A) Enhancing soil fertility
(B) Curing cancer
(C) Wound healing
(D) Purifying water

73. A major ethical concern frequently raised against the use of modern biotechnology in agriculture and medicine is?
(A) Significantly reducing the production efficiency of chemical manufacturing factories
(B) Causing agricultural food products to taste noticeably worse to human consumers
(C) Halting and completely stopping the biological process of natural evolution worldwide
(D) Unforeseen ecological risks and crossing natural species barriers

74. Which of the following is NOT typically considered an ethical or safety concern regarding genetically modified (GM) foods?
(A) The significant increase in the nutritional value of crops
(B) The potential introduction of new allergens into the human diet
(C) The possible transfer of antibiotic resistance genes to gut bacteria
(D) Unpredictable changes in the metabolic pathways of the modified plant

75. The ethical principle of 'Biosafety' in biotechnology primarily focuses on?
(A) Legally ensuring that biotechnology corporations achieve maximum economic profits
(B) Preventing accidental release of harmful genetically modified organisms
(C) Strictly guarding corporate intellectual property rights against international theft
(D) Enforcing global legal prohibitions to ban all recombinant genetic research worldwide

76. Match the following terms in List I with their corresponding concepts in List II:

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List I:
P. Bioethics
Q. Biopiracy
R. Bio-patent
S. Biosafety

List II:
1. Legal monopoly granted over a biological invention
2. Guidelines to prevent harm to health and environment from GMOs
3. Moral principles guiding biological research and applications
4. Unauthorized commercial exploitation of biological resources

(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

77. To combat biopiracy and fulfill international obligations under the Convention on Biological Diversity (CBD), the Parliament of India enacted the Biological Diversity Act in which year?
(A) 1986
(B) 1992
(C) 2002
(D) 2010

78. Under the provisions of the Biological Diversity Act, 2002, which apex body was established to regulate access to India's biological resources and ensure equitable benefit sharing?
(A) Genetic Engineering Appraisal Committee (GEAC)
(B) Indian Council of Agricultural Research (ICAR)
(C) National Biodiversity Authority (NBA)
(D) Forest Survey of India (FSI)

79. The headquarters of the National Biodiversity Authority (NBA) of India is located in which city?
(A) New Delhi
(B) Mumbai
(C) Kolkata
(D) Chennai

80. According to Indian biodiversity conservation laws, a foreign individual or corporation seeking to obtain a bio-patent based on Indian biological resources must?
(A) Provide simple formal notification to the local village panchayat body
(B) Pay a nominal regulatory fee directly to the respective state government
(C) Obtain approval from National Biodiversity Authority
(D) Publish their detailed scientific findings in a peer-reviewed research journal

81. In the context of biotechnology and biopiracy, 'Traditional Knowledge' refers to?
(A) Standard scientific knowledge documented in basic high school biology textbooks
(B) Traditional knowledge passed through generations within a community
(C) Complex computational data generated exclusively by modern supercomputers
(D) Cutting-edge automated DNA sequencing techniques used in modern laboratories

82. Consider the following statements regarding the protection of Traditional Knowledge in India:
I. The Traditional Knowledge Digital Library (TKDL) was created to prevent the granting of wrong patents by international patent offices.
II. TKDL translates ancient Indian texts into languages like English, French, and Japanese.
III. Traditional knowledge cannot be used as prior art to challenge a patent application.
Which of the statements given above is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

83. Protecting the traditional knowledge of local communities, such as the uses of desert medicinal plants in Rajasthan, is crucial primarily to?
(A) Prevent unauthorized commercial exploitation and biopiracy
(B) Prohibit local indigenous communities from utilizing wild medicinal plants
(C) Eradicate natural wild plant populations to make way for modern hybrid crops
(D) Ensure traditional medicinal knowledge remains completely undocumented legally

84. Which of the following accurately describes the 'commercialisation' process of a biotechnology product?
(A) Restricting product development exclusively within small laboratory environments
(B) Authoring and publishing a detailed scientific research paper on the product
(C) Scaling up laboratory research to industrial

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30. Genetically engineered human insulin, produced using recombinant DNA technology, is commercially known as?
(A) Novolin
(B) Glucagon
(C) Humulin
(D) Thyroxine

31. Mature functional human insulin consists of two short polypeptide chains (A and B). How are these two chains linked together?
(A) By hydrogen bonds
(B) By peptide bonds directly between the chains
(C) By phosphodiester bonds
(D) By disulphide bridges

32. Which American pharmaceutical company became the first to successfully produce human insulin using recombinant E. coli in 1983?
(A) Pfizer
(B) Johnson & Johnson
(C) Eli Lilly
(D) Moderna

33. The genetic modification of crops in agriculture is primarily aimed at creating plants that are?
(A) Compact in size for simplified mechanical harvesting
(B) Resistant to abiotic stresses and pests
(C) Highly dependent on synthetic chemical fertilizers
(D) Completely incapable of producing viable seeds

34. Consider the following statements regarding the applications of biotechnology in agriculture:
I. Bt cotton possesses a bacterial gene that makes it resistant to specific insect pests.
II. Golden rice is genetically modified to be enriched with Vitamin A.
III. Genetically modified crops always lead to an increase in the use of chemical pesticides.
Which of the statements given above is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

35. In arid and semi-arid regions like Rajasthan, agricultural biotechnology is of immense importance for developing varieties of crops such as Bajra (Pearl Millet) that primarily exhibit?
(A) High drought and salinity tolerance
(B) Unusually high water consumption rates
(C) Extreme sensitivity to temperature fluctuations
(D) Prolonged and extended vegetative growth phases

36. The 'Bt' in Bt cotton stands for which microorganism from which the insecticidal cry gene is isolated?
(A) Bacteriophage T4
(B) Bifidobacterium thermophilum
(C) Bacillus thuringiensis
(D) Bacillus tropicalis

37. Industrial biotechnology, which focuses on the commercial production of chemicals, materials, and fuels using living cells, is also colloquially known as?
(A) White biotechnology
(B) Red biotechnology
(C) Green biotechnology
(D) Blue biotechnology

38. Match the commercial industrial products in List I with their corresponding microbial sources in List II:
List I:
P. Citric acid
Q. Acetic acid
R. Penicillin
S. Ethanol
List II:
1. Saccharomyces cerevisiae
2. Penicillium notatum
3. Acetobacter aceti
4. Aspergillus niger
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-1, Q-2, R-3, S-4

39. Large stainless-steel vessels where microbes, plant, or animal cells are cultured in vast quantities to yield specific industrial products are known as?
(A) Autoclaves
(B) Bioreactors
(C) Laminar hoods
(D) Centrifuges

40. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

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India

94. Arrange the typical procedural steps for the development and regulatory clearance of a new GM crop in India in the correct order:
I. Final commercial release approval by the GEAC.
II. Confined open field trials (BRL-I and BRL-II) to assess environmental safety.
III. Initial laboratory research and greenhouse testing.
IV. Review and approval by the Review Committee on Genetic Manipulation (RCGM).
(A) III, IV, II, I
(B) III, II, IV, I
(C) IV, III, II, I
(D) II, III, I, IV

95. While GEAC handles environmental release, which body is primarily responsible for monitoring safety related to ongoing recombinant DNA research within institutional laboratories in India?
(A) Food Safety and Standards Authority of India (FSSAI)
(B) Central Pollution Control Board (CPCB)
(C) National Biodiversity Authority (NBA)
(D) Institutional Biosafety Committee (IBSC)

96. Which government department was explicitly established in 1986 under the Ministry of Science and Technology to promote the growth of the biotechnology industry in India?
(A) Department of Space (DoS)
(B) Department of Atomic Energy (DAE)
(C) Department of Biotechnology (DBT)
(D) Department of Agricultural Research and Education (DARE)

97. The Indian biotechnology industry has shown rapid growth and is heavily dominated by which specific sector, accounting for more than half of its revenue?
(A) Agricultural biotechnology (Bio-agriculture)
(B) Bio-pharmaceuticals (Biopharma)
(C) Computational biology (Bio-informatics)
(D) Contract research and clinical Bio-services

98. To foster innovation, support startups, and bridge the gap between research and commercialisation, the Indian government heavily promotes the establishment of?
(A) Industrial Special Economic Zones dedicated to heavy metals
(B) State-run nationalized purely synthetic chemical plants
(C) Specialized centers dedicated to traditional Ayurvedic ashrams
(D) Biotech Parks and Technology Incubators

99. Which of the following autonomous research institutions in India is globally recognized for its premier research in cellular and molecular biology?
(A) Centre for Cellular and Molecular Biology (CCMB), Hyderabad
(B) National Institute of Oceanography (NIO) research facility, Goa
(C) Forest Research Institute (FRI) central campus, Dehradun
(D) Central Building Research Institute (CBRI) complex, Roorkee

100. Match the premier Indian research institutes in List I with their respective locations in List II:
List I:
P. National Institute of Immunology (NII)
Q. Centre for Cellular and Molecular Biology (CCMB)
R. National Centre for Cell Science (NCCS)
S. Central Arid Zone Research Institute (CAZRI)
List II:
1. Pune
2. New Delhi
3. Jodhpur
4. Hyderabad
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

101. The National Institute of Immunology (NII) in New Delhi focuses its biotechnology research primarily on?
(A) Understanding immune mechanisms and developing novel vaccines
(B) Breeding high-yielding disease-resistant modern crop varieties of wheat
(C) Extracting valuable commercial minerals directly from oceanic seawater
(D) Designing advanced high-efficiency mechanical agricultural tractors

102. In the context of Rajasthan, agricultural biotechnology research focusing on developing crops suited for extreme desert conditions and

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9. (D) Modern biotechnology involves direct genetic manipulation of DNA or RNA
Traditional biotechnology relies on natural micro-organismal metabolic activities and conventional cross-breeding techniques to achieve desired traits. In contrast, modern biotechnology fundamentally relies on recombinant DNA technology and genetic engineering. This allows scientists to alter, transfer, or insert specific nucleotide sequences directly into nucleic acids, transcending species boundaries and enabling precise cellular modifications.

10. (A) I and II only
Traditional biotechnology leverages the inherent metabolic capabilities of microorganisms to yield products like curd, bread, and wine without synthetic chemicals. Modern biotechnology employs recombinant DNA technology to recombine genetic material across natural species barriers. Because traditional methods utilize living cells and natural biological processes rather than pure synthetic chemicals, statement III is completely inaccurate.

11. (B) Human insulin produced by E. coli
Human insulin produced by genetically engineered Escherichia coli represents a definitive milestone of modern biotechnology. Unlike traditional biological products derived from natural fermentation like bread, wine, or compost, this therapeutic protein is synthesized by inserting human gene sequences into bacterial plasmids, enabling host bacterial cells to synthesize human functional insulin polypeptides.

12. (B) Agrobacterium tumefaciens
Agrobacterium tumefaciens is known as nature's genetic engineer because of its natural ability to transfer a specific segment of its Ti plasmid, called T-DNA, into plant genomes. In nature, this induces crown gall tumors. Modern plant biotechnologists modify this Ti plasmid, replacing tumor-inducing genes with desired target genes to transform plant cells efficiently.

13. (A) Combining foreign DNA fragments and inserting them into a host organism
Recombinant DNA technology involves isolating specific DNA fragments from a donor organism, joining them with vector DNA, and introducing the constructed recombinant molecule into a suitable host cell. Once inside, the host replicates the foreign DNA and expresses encoded traits, enabling the production of desired proteins, therapeutic compounds, or genetically modified traits.

14. (C) Vector
In molecular cloning, a vector acts as a vehicle to transport foreign DNA fragments into host cells. Plasmids and bacteriophages are widely used vectors because they possess autonomous replication origins, selectable marker genes, and recognition sites for restriction endonucleases. Vectors ensure the stable maintenance and replication of foreign genetic constructs within transformed hosts.

15. (D) It joins sugar-phosphate backbones of two DNA fragments
DNA ligase plays a critical role in recombinant DNA technology by catalyzing the formation of phosphodiester bonds between adjacent nucleotides. It covalently seals nicks in the sugar-phosphate backbone, linking foreign DNA fragments to vector DNA molecules. This enzymatic ligation creates stable recombinant DNA constructs essential for gene cloning and expression applications.

16. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Plasmids are extensively utilized as cloning vectors in genetic engineering because they exist as extra-chromosomal, self-replicating circular double-stranded DNA molecules in bacteria. Their ability to replicate independently of host chromosomal DNA allows them to amplify foreign genes inserted into them, making autonomous replication a primary reason for their selection as vectors.

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17. (B) Multiple identical copies of a specific gene or DNA segment
Gene cloning is the process of isolating a specific gene or DNA fragment and generating numerous identical genetic copies of it. By inserting the target gene into a cloning vector and introducing it into host cells, the gene multiplies as host cells divide, allowing scientists to study gene structure and synthesize proteins.

18. (D) Transformed cell
When a host cell successfully incorporates a foreign recombinant plasmid into its cytoplasm, the cell is referred to as a transformed cell. Transformation alters the host cell's genetic

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List I:
P. Biostimulation
Q. Bioaugmentation
R. Phytoremediation
S. Bioleaching
List II:
1. Using plants to remove pollutants from the soil
2. Adding specific engineered microbes to a contaminated site
3. Adding nutrients to the soil to stimulate native microbes
4. Using microbes to extract metals from low-grade ores

(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-2, R-4, S-3

113. Which of the following is NOT a recognized method or application of bioremediation?
(A) Utilizing specialized microorganisms to degrade marine oil spills
(B) Incinerating chemical waste in industrial furnaces
(C) Deploying hyperaccumulating plants to extract heavy metals from soil
(D) Aerobic composting of solid municipal organic waste material

114. A revolutionary future application of biotechnology, which functions as highly precise "molecular scissors" capable of editing genes by cutting DNA at specific targeted locations, is known as?
(A) Gel Electrophoresis
(B) Western Blotting
(C) Centrifugation
(D) CRISPR-Cas9

115. What is the fundamental concept behind the futuristic biotechnology application known as 'Personalized Medicine'?
(A) Tailoring treatments based on an individual's unique genetic profile
(B) Manufacturing pharmaceutical pills with unique color coding for individual patients
(C) Providing customized high-end nursing and medical care within patient residences
(D) Utilizing traditional indigenous herbal remedies exclusively for all clinical diseases

116. In the field of computing, a highly promising future application of biotechnology explores the use of which biological molecule as an ultra-dense, long-term digital data storage medium?
(A) Cellulose
(B) Lipids
(C) DNA (Deoxyribonucleic Acid)
(D) Chlorophyll

117. An emerging biotechnology field aimed at addressing global meat demand and environmental concerns involves growing real animal tissue from stem cells in a bioreactor without slaughtering animals. This is commonly referred to as?
(A) Cultured meat or lab-grown meat
(B) Synthetic botany and cellular agriculture
(C) Highly processed plant-based meat analogues
(D) Traditional livestock farming and animal husbandry

118. Match the futuristic biotechnology concepts in List I with their intended applications in List II:
List I:
P. CRISPR-Cas9
Q. Gene Drive
R. Synthetic Biology
S. DNA Computing
List II:
1. Rapidly altering the genetics of an entire wild population (e.g., mosquitoes)
2. Precise and targeted genome editing tool
3. Using biological molecules for massive data storage and complex calculations
4. Designing and constructing new biological parts, devices, and systems

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-1, R-2, S-3

119. Which futuristic application of biotechnology aims to reconstruct completely extinct species (such as the Woolly Mammoth) by extracting their residual DNA and using related surrogate hosts?
(A) Environmental bioremediation techniques
(B) De-extinction (Resurrection biology)
(C) Plant-based phytoremediation processes
(D) Nutritional crop biofortification methods

120. Which of the following statements about the future of biotechnology is highly unlikely based on current scientific principles?
(A) Integrating biotechnology with artificial intelligence to accelerate drug discovery

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(B) Deploying nanobiotechnology to enable precise targeted drug delivery at cellular levels
(C) Humans will stop aging and achieve biological immortality in two years
(D) Developing precise gene therapy tools for widespread treatment of inherited diseases

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ANSWERS

1. (B) Molecular analogues
The European Federation of Biotechnology defined biotechnology to encompass both traditional views and modern molecular developments. According to this comprehensive definition, biotechnology is the integration of natural science along with organisms, cells, parts thereof, and molecular analogues for products and services. This unified framework links classical fermentation techniques with modern recombinant genetic technologies effectively.

2. (D) Genetic engineering and bioprocess engineering
Modern biotechnology relies on two primary core techniques that revolutionized biological applications. Genetic engineering alters the chemistry of genetic material to introduce host organisms with desired traits. Bioprocess engineering maintains sterile, contamination-free conditions in industrial processes to enable the growth of specific microorganisms or cells for manufacturing therapeutic proteins, enzymes, and vaccines efficiently.

3. (A) Therapeutics, diagnostics, GM crops, and bioremediation
Modern biotechnology encompasses a wide array of multidisciplinary fields across diverse industries. Its application spans medical healthcare through therapeutics and diagnostic kits, agricultural systems via genetically modified crop varieties, and environmental preservation through bioremediation techniques. This comprehensive reach demonstrates how molecular tools optimize human health, sustainable agriculture, and ecological restoration simultaneously.

4. (C) Karl Ereky
The term biotechnology was first coined in 1919 by Karl Ereky, a Hungarian agricultural engineer. He used it to describe a process in which biological raw materials could be converted into useful commercial products, specifically referring to large-scale pig farming integrated with sugar beet feeding. His visionary concept laid the historical foundation for modern industrial biotechnology.

5. (A) Salmonella typhimurium
In 1972, Stanley Cohen and Herbert Boyer successfully created the world's first recombinant DNA molecule. They isolated an antibiotic resistance gene from a plasmid of Salmonella typhimurium and linked it to a plasmid vector. This constructed recombinant plasmid was subsequently transferred into Escherichia coli cells, proving that foreign DNA could replicate within a host organism.

6. (A) P-3, Q-1, R-4, S-2
Historical achievements in biological sciences reflect major scientific breakthroughs across distinct eras. Stanley Cohen and Herbert Boyer constructed the first recombinant DNA molecule in 1972. Kary Mullis invented the Polymerase Chain Reaction in 1983 for amplifying DNA. Ian Wilmut successfully cloned Dolly the sheep in 1996, while Alexander Fleming discovered the antibiotic penicillin in 1928.

7. (B) Making curd using lactic acid bacteria
Traditional biotechnology utilizes naturally occurring microorganisms to carry out bio-fermentation processes without targeted genomic manipulation. Converting milk into curd using lactic acid bacteria like Lactobacillus is an ancient practice spanning thousands of years. The bacteria ferment lactose into lactic acid, coagulating milk proteins and transforming the texture and nutrient profile through natural biological activity.

8. (C) Restriction endonucleases
The discovery of restriction endonucleases in the late 1960s provided the fundamental foundation for modern genetic engineering. Scientists isolated these bacterial enzymes, which cut double-stranded DNA at precise nucleotide sequences. This capability allowed researchers to isolate specific gene fragments and recombine them with precision, laying the essential groundwork for recombinant DNA technology and molecular cloning.

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water scarcity is largely supported by which central institute located in Jodhpur?
(A) National Institute of Virology (NIV)
(B) Central Drug Research Institute (CDRI)
(C) National Botanical Research Institute (NBRI)
(D) Central Arid Zone Research Institute (CAZRI)

103. A major environmental benefit of using genetically modified crops like Bt Cotton is?
(A) Increased long-term dependency on synthetic chemical nitrogen fertilizers
(B) Significant reduction in chemical insecticide usage
(C) Complete agricultural elimination of any requirement for crop irrigation
(D) Substantial increase and enhanced emission of atmospheric greenhouse gases

104. Which of the following is considered a primary socio-economic limitation of implementing modern biotechnology in agriculture?
(A) Genetically modified crop plants mature and grow far too fast for farmers to harvest
(B) Biotechnology crops produce significantly lower annual yields than traditional crops
(C) GM seeds are proprietary, costly, and repurchased each season
(D) Biopesticides permanently degrade and destroy long-term agricultural soil fertility

105. What is a notable biological limitation or risk associated with the widespread, continuous cultivation of insect-resistant GM crops?
(A) GM crop plants will eventually transform into completely different weed species
(B) Modified crops will start parasitically consuming nutrients from neighboring plants
(C) Agricultural soil will permanently lose its natural moisture and water-holding capacity
(D) Target pests may evolve resistance to GM toxins over time

106. Consider the following statements regarding the benefits and limitations of biotechnology:
I. Recombinant therapeutics do not induce unwanted immunological responses unlike animal-derived drugs.
II. One limitation of gene therapy is that some viral vectors can trigger adverse immune reactions in patients.
III. Genetically modified organisms pose zero risk to natural biodiversity under any circumstances.
Which of the statements given above is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

107. The branch of biotechnology that utilizes biological systems, living organisms, or parts of this to monitor, clear, and protect the environment from pollution is known as?
(A) Medical Biotechnology
(B) Environmental Biotechnology
(C) Agricultural Biotechnology
(D) Bioinformatics

108. The specific process of using naturally occurring or genetically engineered microorganisms to consume and break down environmental pollutants into less toxic substances is called?
(A) Biomagnification
(B) Bioremediation
(C) Biopiracy
(D) Biosynthesis

109. Which genetically engineered bacterium, often dubbed a 'superbug', was famously developed to degrade hydrocarbons and clean up marine oil spills?
(A) Pseudomonas putida
(B) Agrobacterium tumefaciens
(C) Escherichia coli
(D) Bacillus subtilis

110. Phytoremediation is an eco-friendly biotechnology technique that specifically uses which of the following to clean up contaminated soil and water?
(A) Genetically modified fungi
(B) Heavy industrial machinery
(C) Living plants
(D) Synthetic chemical filters

111. Methanogenic bacteria play a crucial role in environmental biotechnology by converting organic waste, such as sewage and agricultural residue, into?
(A) Purified atmospheric liquid oxygen
(B) Biodegradable synthetic plastics
(C) High-density solid mineral coal
(D) Biogas (predominantly methane)

112. Match the bioremediation techniques in List I with their descriptions in List II:

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profile. Competent cells are host cells prepared to take up DNA, while transformed cells have already taken up and stabilized the foreign plasmid.

19. (A) Polymerase Chain Reaction
PCR stands for Polymerase Chain Reaction, a revolutionary molecular biology technique developed by Kary Mullis in 1983. It permits automated exponential amplification of target DNA sequences in vitro. Utilizing cycles of denaturation, primer annealing, and enzymatic extension with heat-stable Taq DNA polymerase, PCR generates billions of identical DNA copies rapidly.

20. (C) ori (origin of replication)
The origin of replication, commonly abbreviated as ori, is a specific nucleotide sequence within a vector where replication initiates. Any DNA segment linked to the ori sequence will replicate along with the vector during host cell division. Furthermore, the ori sequence dictates the copy number of linked recombinant DNA within transformed host cells.

21. (A) Restriction endonucleases
Restriction endonucleases are popularly termed molecular scissors because they precisely recognize and cleave double-stranded DNA at specific palindromic nucleotide sequences. By cutting DNA strands at targeted sites, these bacterial enzymes allow geneticists to cut out desired target genes and open vector plasmids cleanly, facilitating the precise assembly of recombinant DNA molecules.

22. (A) II, IV, III, I
When a restriction endonuclease operates, it first inspects the entire length of a DNA strand to locate its specific recognition sequence. Upon recognizing the target palindromic nucleotide arrangement, the enzyme binds tightly to the site. Finally, it cleaves both strands of the sugar-phosphate backbone at specific sites to yield cut DNA fragments.

23. (B) Sticky ends
Staggered cuts made by restriction endonucleases across DNA strands create short single-stranded terminal extensions known as sticky ends. These overhanging sequences form complementary hydrogen bonds with matching single-stranded overhangs produced by the same restriction enzyme on foreign DNA. This base-pairing affinity greatly facilitates subsequent ligation by DNA ligase during cloning operations.

24. (A) P-2, Q-4, R-1, S-3
Exonucleases remove terminal nucleotides from DNA ends, whereas endonucleases cut internal phosphodiester bonds at specific target sequences. DNA ligase joins separate DNA fragments by creating covalent phosphodiester bonds between backbones. DNA polymerase synthesizes new DNA strands complementary to single-stranded templates during cell division or in vitro amplification techniques like PCR.

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25. (D) Palindromic nucleotide sequence
A palindromic nucleotide sequence is a specific DNA sequence that reads identically on both complementary strands when read in the 5' to 3' direction. Restriction endonucleases inspect and recognize these symmetrical sequences specifically, cleaving both strands between the same bases on opposite strands to produce sticky or blunt ends consistently.

26. (A) Recombinant therapeutics
Recombinant therapeutics are biological drugs synthesized using genetically modified host organisms expressing human genes. Because these therapeutic proteins, such as human insulin or growth factors, are structurally identical to natural human molecules, they do not trigger adverse immunological reactions, unlike non-human animal-derived protein preparations previously utilized in medical treatments.

27. (B) Delivering a functional gene into cells to correct a defective one
Gene therapy represents a modern medical intervention designed to address underlying genetic diseases at their source. The process involves inserting functional, therapeutic genes into a patient's target cells or tissues using modified vectors to substitute or compensate for mutated, non-functional genes, thereby restoring normal biological function and producing required proteins.

28. (B) Adenosine deaminase (ADA)
In 1990, the first clinical gene therapy was administered to a four-year-old girl suffering from Severe Combined Immunodeficiency caused by adenosine deaminase deficiency. Lymphocytes extracted from her blood were transformed

with a functional ADA gene using a retroviral vector and reinfused, restoring immune function by supplying the missing enzyme essential for lymphocyte maturation.

29. (A) Insulin
Recombinant human insulin was the first genetically engineered human medicine approved for commercial healthcare application in 1982. Prior to this innovation, diabetic patients received insulin extracted from bovine or porcine pancreases, which frequently caused allergic reactions. Producing identical human insulin through recombinant DNA technology provided a safe, pure, and scalable therapeutic solution.

30. (C) Humulin
Humulin is the registered commercial brand name for synthetic human insulin manufactured through recombinant DNA technology. Synthesized inside transformed Escherichia coli host cells, Humulin matches human physiological insulin precisely. Its widespread commercial availability replaced slaughterhouse-derived animal insulin, providing diabetic patients worldwide with a safer, standardized, and non-allergenic hormone therapy.

31. (D) By disulphide bridges
Mature functional human insulin comprises two distinct polypeptide chains, chain A with 21 amino acids and chain B with 30 amino acids. These separate peptide chains are held together covalently by interchain disulphide bridges between cysteine residues. In recombinant manufacturing, chains A and B are expressed separately before being chemically linked via disulphide bonds.

32. (C) Eli Lilly
In 1983, Eli Lilly and Company became the first commercial pharmaceutical manufacturer to synthesize human insulin using recombinant DNA technology. They constructed separate DNA sequences corresponding to insulin A and B chains, introduced them into Escherichia coli plasmids, extracted the expressed peptide chains individually, and combined them by forming disulphide linkages.

33. (B) Resistant to abiotic stresses and pests
Agricultural genetic engineering aims to enhance crop productivity, resilience, and sustainability. Modifying plant genomes enables crops to withstand severe abiotic stresses such as drought, high salinity, and cold temperatures. Furthermore, introducing specific insecticidal or disease-resistant foreign genes protects crops from insect pests, thereby reducing dependence on harmful chemical pesticides in farming.

34. (A) I and II only
Bt cotton incorporates a bacterial gene encoding insecticidal endotoxin proteins that protect plants against bollworms. Golden rice is engineered to express beta-carotene, a precursor to Vitamin A, combating nutritional deficiency. Statement III is false because pest-resistant GM crops reduce overall chemical pesticide consumption significantly by conferring natural resistance against insect pests.

35. (A) High drought and salinity tolerance
Regions characterized by arid climates and saline soils, such as Rajasthan, require crop varieties capable of surviving extreme environmental constraints. Agricultural biotechnology develops bioengineered millet and pearl millet (Bajra) varieties exhibiting enhanced drought and salinity tolerance. These stress-resilient traits ensure stable crop yields, conserve water resources, and bolster regional food security under desert conditions.

36. (C) Bacillus thuringiensis
The prefix 'Bt' in Bt cotton denotes Bacillus thuringiensis, a ubiquitous soil bacterium. This bacterium naturally synthesizes crystal endotoxin proteins during sporulation. The cry genes responsible for producing these insecticidal toxins are isolated from Bacillus thuringiensis and transferred into crop genomes, enabling plants to produce protective endotoxins that kill targeted insect pests.

37. (A) White biotechnology
Industrial biotechnology is widely categorized as white biotechnology. It focuses on using living organisms, such as bacteria, yeasts, and fungi, or isolated enzymes, to manufacture industrial chemicals, bioplastics, biofuels, and textiles. White biotechnology emphasizes eco-friendly manufacturing processes, reduced energy usage, and sustainable alternatives to traditional petroleum-based chemical production methods.

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38. (A) P-4, Q-3, R-2, S-1
Commercial biochemical production employs specific microorganisms for target fermentations. The fungus Aspergillus niger synthesizes citric acid efficiently. Acetobacter aceti oxidizes ethanol into acetic acid. Penicillium notatum produces the antibiotic penicillin, while the yeast Saccharomyces cerevisiae ferments carbohydrates into ethanol, serving key roles across beverage, pharmaceutical, and chemical industries.

39. (B) Bioreactors
Bioreactors are large-scale closed vessels designed to cultivate microorganisms, plant cells, or animal cells under controlled optimal conditions. They maintain precise temperature, pH, dissolved oxygen, and nutrient concentrations required for maximum cell growth and product yield. Bioreactors enable the efficient commercial production of recombinant therapeutic proteins, enzymes, and industrial biochemicals.

40. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Downstream processing is an essential final stage in industrial biotechnology operations. Following biosyntheses in bioreactors, crude biological mixtures must undergo rigorous separation, purification, and quality control steps to yield safe, concentrated, and stable final products. These purification and preservation processes ensure product compliance with commercial, medical, and safety standards before release.

41. (D) Microorganisms that enrich the nutrient quality of soil
Biofertilisers are living inoculants containing selected microorganisms such as bacteria, fungi, or cyanobacteria. When applied to seeds, plant surfaces, or soil, these beneficial microbes colonize the rhizosphere, fix atmospheric nitrogen, solubilize insoluble soil phosphorus, or synthesize growth-promoting substances, thereby increasing soil fertility and enhancing crop nutrient uptake naturally and sustainably.

42. (A) P-2, Q-1, R-4, S-3
Different biofertilisers enhance soil fertility through distinct biological mechanisms. Rhizobium forms root nodule symbioses with leguminous plants to fix atmospheric nitrogen. Azotobacter is a free-living nitrogen-fixing soil bacterium. Mycorrhizal fungi establish symbiotic root associations that boost phosphorus absorption, while the aquatic fern Azolla harbors nitrogen-fixing cyanobacteria inside its leaf cavities.

43. (B) Target specific pests safely without harming non-target organisms
Biopesticides derived from natural biological sources such as microbes, plants, or specific minerals offer significant eco-friendly advantages. Unlike broad-spectrum chemical insecticides, biopesticides exhibit high target specificity against targeted agricultural pests. They degrade rapidly in the environment without leaving persistent toxic residues, safeguarding beneficial insects, birds, mammals, soil ecosystems, and agricultural workers.

44. (A) I and II only
Trichoderma species are free-living soil fungi used effectively as biological control agents against plant pathogenic fungi. Cyanobacteria like Anabaena and Nostoc fix atmospheric nitrogen, enriching soil fertility in flooded paddy fields. Statement III is incorrect because urea and superphosphate are synthetic inorganic chemical fertilizers rather than living microbial biofertilisers.

45. (A) Contain purified antigen proteins without pathogenic organisms
Recombinant DNA vaccines, such as the recombinant Hepatitis B surface antigen vaccine, offer superior safety compared to traditional live-attenuated or killed pathogen vaccines. They consist exclusively of purified antigenic subunit proteins produced by engineered host cells. Because no live or inactivated intact pathogens are introduced, there is zero risk of pathogen replication or disease reversion.

46. (B) Isolation of antigen gene → Insertion into a vector → Expression in host cells → Purification
Producing a recombinant protein vaccine follows a systematic molecular sequence. First, the specific antigen-encoding gene is isolated from the target pathogen. Next, this gene is inserted into a suitable expression vector. The recombinant vector is introduced into expression host cells for protein synthesis, followed by downstream purification of the antigenic protein.

47. (D) Saccharomyces cerevisiae (Yeast)
The commercial recombinant Hepatitis B vaccine is produced primarily using the budding yeast

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Saccharomyces cerevisiae as a host organism. The gene encoding Hepatitis B surface antigen is inserted into a yeast plasmid vector. Transformed yeast cells express the recombinant protein, which self-assembles into antigenic virus-like particles that trigger effective immune protection.

48. (C) Modifying edible plants to express antigens that trigger immunity when eaten
Edible vaccines represent an innovative biotechnology application where foreign antigenic genes from pathogens are introduced into edible plant genomes like bananas, potatoes, or tomatoes. When consumed orally without cooking, these transgenic plants present surface antigens to the mucosal immune system in the gut, stimulating systemic protective immunity economically without requiring sterile needles.

49. (B) Explant
In plant tissue culture, an explant refers to any excised plant fragment, such as a shoot tip, leaf segment, or root tip, selected to initiate in vitro cultures. Explants are surface-sterilized and placed onto nutrient-rich artificial growth media under aseptic conditions, where cellular division yields callus tissue or direct organogenesis.

50. (D) Totipotency
Totipotency is the fundamental cellular capacity of a single living plant cell to divide, differentiate, and regenerate into a fully functional, complete whole plant organism. This unique genetic property forms the cellular foundation of plant tissue culture and micropropagation, enabling identical plant clones to develop under controlled in vitro nutrient conditions.

51. (A) Micropropagation
Micropropagation is a tissue culture technique used to rapidly multiply large quantities of genetically identical plants from small explants. By manipulating plant growth regulators such as auxins and cytokinins in sterile media, thousands of plantlets develop rapidly. This method enables mass propagation of disease-free elite crop varieties, ornamental species, and forestry trees.

52. (A) P-2, Q-1, R-4, S-3
In plant tissue culture terminology, a callus is an unorganized mass of proliferating undifferentiated cells. Somaclones are regenerated plants genetically identical to the parent explant source. A protoplast is an isolated plant cell whose cell wall has been enzymatically digested, and nutrient media provide essential inorganic salts, carbon sources, and vitamins.

53. (A) Self-renew endlessly and differentiate into specialized cell types
Stem cells are unspecialized biological cells distinguished by two defining capabilities. First, they undergo long-term self-renewal through repeated cell division while maintaining an undifferentiated state. Second, under specific physiological or experimental signals, stem cells differentiate into specialized mature cell types, such as cardiac, neural, muscle, or blood cells, for tissue repair.

54. (D) Inner cell mass of a blastocyst
Pluripotent embryonic stem cells are isolated from the inner cell mass of an early-stage embryo known as a blastocyst. At this stage of development, these cells retain the remarkable capacity to differentiate into derivative cell lineages of all three germ layers: ectoderm, mesoderm, and endoderm, giving them tremendous potential in regenerative medicine.

55. (B) Bone marrow
Bone marrow is one of the richest and most widely utilized sources of adult stem cells in clinical medicine. It harbors hematopoietic stem cells, which generate all mature blood cell lineages, as well as mesenchymal stem cells capable of forming bone, cartilage, and fat tissues. Bone marrow harvests support life-saving medical transplantation therapies.

56. (C) Hematopoietic stem cells from bone marrow
Hematopoietic stem cell transplantation is a well-established, standard biological therapy used globally to treat blood disorders such as leukemia, lymphoma, and aplastic anemia. Transplanting healthy hematopoietic stem cells derived from bone marrow or umbilical cord blood reconstitutes the patient's destroyed bone marrow, restoring normal red blood cell, white blood cell, and platelet production.

57. (D) An exclusive legal right granted to an inventor to exploit an invention for a set period
A patent is an exclusive intellectual property right granted by a sovereign government to an inventor for a limited term, typically twenty years. In exchange for publicly disclosing technical details of the invention, the patent

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owner gains legal authority to prevent others from making, using, selling, or importing the patented technology without permission.

58. (B) I and III only
Patents grant inventors exclusive legal protection against unauthorized commercial exploitation by third parties. To qualify for patent protection, an invention must satisfy three criteria: novelty, non-obvious inventive step, and industrial applicability. Statement II is incorrect because standard Indian patent law specifies a protection term of twenty years from filing, not fifty years.

59. (B) Human intellectual creations like inventions, literary works, and designs
Intellectual Property Rights (IPR) are legal rights designed to safeguard intangible creations of human intellect. They encompass patents for technological inventions, copyrights for creative literary and artistic works, trademarks for brand identifiers, and industrial designs. IPR encourages innovation and economic investment by providing creators with legal protection and financial incentives.

60. (B) Discovery of a natural wild plant or animal
Under Section 3 of the Indian Patents Act, 1970, the mere discovery of a naturally occurring living entity or non-living substance in nature, including wild plants and animals, is not considered an invention and cannot be patented. Biological discoveries exist naturally without human inventive contribution, distinguishing them from patentable man-made biotechnological inventions.

61. (A) Biological materials, processes, and genetically modified organisms
A bio-patent is a specialized patent granted by government authorities for biological inventions, including isolated genes, genetically modified microorganisms, modified plant or animal strains, recombinant cell lines, and biological manufacturing processes. Bio-patents provide legal monopoly rights over proprietary biological constructs, encouraging investment in biological research, pharmaceuticals, and agricultural developments.

62. (C) An oil-eating Pseudomonas bacterium developed by Ananda Chakrabarty
The landmark 1980 US Supreme Court case Diamond v. Chakrabarty established that genetically engineered living organisms are patentable subject matter. Ananda Chakrabarty developed a genetically modified Pseudomonas bacterium capable of degrading multiple hydrocarbon components in crude oil spills. This historic decision opened the door to commercial bio-patenting in modern global biotechnology industries.

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63. (D) Safeguarding private investments and driving technological innovation
Bio-patents provide vital commercial incentives within biotechnology by protecting research investments. Developing biotechnology products demands extensive financial expenditure, scientific labor, and lengthy testing periods. By offering temporary market exclusivity, bio-patents allow companies to recover R&D costs and generate profits, thereby driving continuous innovation and technological advancement across healthcare and agriculture.

64. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Patenting genetically modified agricultural seed varieties has raised socio-economic concerns globally, particularly among smallholder farming communities. Bio-patents grant exclusive commercial monopolies to corporate seed developers, legally prohibiting farmers from saving, reselling, or exchanging harvested seeds. Consequently, farmers become financially dependent on purchasing costly patented seed stocks every planting season.

65. (B) WIPO (World Intellectual Property Organization)
The World Intellectual Property Organization, headquartered in Geneva, Switzerland, is a specialized agency of the United Nations. WIPO promotes global intellectual property protection by harmonizing international patent legislation, administering international treaties like the Patent Cooperation Treaty, and fostering cooperation among member nations to safeguard intellectual, industrial, and artistic properties effectively.

66. (D) Copyright
Copyright is a legal form of intellectual property protection granted automatically to authors and creators of original expression. It covers literary works, dramatic scripts, musical compositions, artistic paintings, photographs, and software

code. Copyright prevents unauthorized copying, reproduction, distribution, or public performance, granting creators exclusive control over their original creative works.

67. (A) Originating from a specific region and having distinct qualities from that origin
A Geographical Indication is an intellectual property right identifying goods as originating from a specific geographic territory or region. The unique quality, reputation, or physical characteristics of the product are essentially attributable to its geographical origin, natural environmental factors, or traditional processing methods, as seen in Darjeeling tea or Alphonso mangoes.

68. (C) Exploiting bio-resources and traditional knowledge without authorization or compensation
Biopiracy describes the unauthorized commercial exploitation of biological resources and associated indigenous traditional knowledge by foreign corporations or entities without appropriate authorization, consent, or equitable benefit-sharing. It deprives indigenous communities and developing countries of their rightful commercial rights and heritage over native bio-resources developed over generations.

69. (A) Basmati Rice
A prominent biopiracy controversy involved a US firm that obtained a patent in 1997 on Basmati rice lines and grains. Basmati is a distinct long-grained aromatic rice traditionally cultivated by Indian farmers for centuries. India successfully challenged the patent, leading to the cancellation of broad patent claims that threatened Indian agricultural export markets.

70. (B) Identification of indigenous knowledge → Collection of bio-resources → Unauthorized patenting → Commercial exploitation
Acts of biopiracy follow a recognizable procedural sequence. Foreign entities first identify valuable indigenous traditional knowledge regarding biological properties. Next, they collect local biological samples from host regions without formal agreements. They then file unauthorized patent applications in foreign jurisdictions, culminating in commercial manufacturing and market exploitation without sharing revenues with original custodians.

71. (B) Council of Scientific and Industrial Research (CSIR)
The Council of Scientific and Industrial Research led India's landmark legal battles against foreign patents granted on traditional bio-resources. CSIR presented historical ancient texts and scientific evidence establishing prior art, successfully forcing international patent offices to revoke wrongfully granted patents on the wound-healing properties of turmeric and anti-fungal uses of neem tree extracts.

72. (C) Wound healing
The turmeric patent controversy arose when the United States Patent and Trademark Office granted a patent in 1995 for using turmeric powder to heal wounds. Indian scientists from CSIR challenged this claim, presenting ancient Ayurvedic literature proving that turmeric's wound-healing properties had been part of traditional Indian knowledge for centuries, forcing the patent's revocation.

73. (D) Unforeseen ecological risks and crossing natural species barriers
Major ethical and ecological concerns regarding modern biotechnology revolve around transferring genes across natural species barriers. Opponents argue that creating transgenic organisms may disrupt natural ecosystems, trigger unintended gene flow to wild relatives, harm non-target organisms, reduce biodiversity, and generate unpredictable consequences for human health and long-term environmental sustainability.

74. (A) The significant increase in the nutritional value of crops
Increasing the nutritional profile of crops is a positive agricultural goal rather than a safety risk or ethical concern. In contrast, genuine safety concerns regarding genetically modified foods involve potential allergenicity in consumers, potential horizontal transfer of antibiotic resistance marker genes to gut microbiota, and unpredictable metabolic changes in modified organisms.

75. (B) Preventing accidental release of harmful genetically modified organisms
Biosafety principles encompass administrative policies, physical containment levels, and ecological guidelines established to prevent accidental release or exposure to potentially hazardous genetically modified organisms.

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Biosafety regulatory frameworks ensure that research, field testing, and commercial utilization of GMOs are conducted safely without compromising human health, animal welfare, or natural ecological stability.

76. (A) P-3, Q-4, R-1, S-2
Bioethics provides moral principles guiding biological research applications. Biopiracy refers to unauthorized commercial exploitation of native bio-resources and traditional knowledge. A bio-patent grants temporary exclusive legal rights over biological inventions, while biosafety enforces regulatory guidelines and physical containment measures to prevent environmental or health damage from genetically modified organisms.

77. (C) 2002
To fulfill its commitments under the 1992 United Nations Convention on Biological Diversity, the Parliament of India enacted the Biological Diversity Act in 2002. This legislation provides a comprehensive legal framework to conserve biological diversity, regulate access to native bio-resources and associated traditional knowledge, and ensure fair, equitable sharing of commercial benefits.

78. (C) National Biodiversity Authority (NBA)
The Biological Diversity Act, 2002 established the National Biodiversity Authority as India's apex statutory regulatory body. The NBA regulates access to Indian biological resources and traditional knowledge, reviews applications for foreign bio-patents based on Indian bio-resources, and ensures that financial or technical benefits arising from their commercial use are shared equitably with local communities.

79. (D) Chennai
The National Biodiversity Authority of India was established in 2003 and has its official headquarters located in Chennai, Tamil Nadu. Operating as an autonomous statutory body under the Ministry of Environment, Forest and Climate Change, the NBA oversees biodiversity conservation, regulates sustainable biological resource utilization, and approves commercial or research access applications.

80. (C) Obtain approval from National Biodiversity Authority
Under Indian biodiversity laws, any foreign individual, non-resident entity, or foreign corporation seeking to obtain intellectual property rights based on Indian biological resources or traditional knowledge must obtain prior approval from the National Biodiversity Authority. The NBA evaluates such applications to prevent biopiracy and enforce binding equitable benefit-sharing agreements before granting consent.

81. (B) Traditional knowledge passed through generations within a community
Traditional Knowledge represents cumulative wisdom, innovations, and practices developed, preserved, and passed down through successive generations within local or indigenous communities. In biotechnology, it frequently pertains to the medicinal uses of flora, crop breeding practices, and natural pest control techniques, serving as a valuable foundation for pharmaceutical and agricultural innovations.

82. (A) I and II only
India established the Traditional Knowledge Digital Library to document traditional medicinal knowledge and prevent wrongful patent grants abroad. TKDL translates ancient Indian texts into multiple international languages, making this information accessible to patent examiners globally. Statement III is false because TKDL serves specifically as prior art to challenge and invalidate improper patent applications.

83. (A) Prevent unauthorized commercial exploitation and biopiracy
Protecting traditional knowledge, such as the indigenous medicinal applications of desert plants in Rajasthan, is crucial to prevent unauthorized commercial exploitation and biopiracy by global entities. Formal documentation and legal protection ensure that local communities retain rights over their heritage and receive fair compensation whenever their traditional remedies are commercialized.

84. (C) Scaling up laboratory research to industrial manufacturing and marketing
The commercialisation of a biotechnology product describes the complete transition from small-scale laboratory discovery to industrial manufacturing and public commercial marketing.

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(B) An endemic floral species
(C) A purebred parent organism
(D) A transgenic organism

21. Which soil bacterium is most commonly used as a vector to transfer foreign genes into plant cells?
(A) Escherichia coli
(B) Rhizobium leguminosarum
(C) Agrobacterium tumefaciens
(D) Azotobacter vinelandii

22. What is the specific segment of DNA in the Ti plasmid of Agrobacterium that is transferred and integrated into the plant genome?
(A) c-DNA
(B) T-DNA
(C) r-DNA
(D) m-DNA

23. Which was the first genetically modified crop approved for human consumption, known for its delayed ripening trait?
(A) Golden Rice
(B) Bt Brinjal
(C) StarLink Corn
(D) Flavr Savr Tomato

24. The delayed ripening in the Flavr Savr tomato was achieved by silencing the gene responsible for producing which enzyme?
(A) Polygalacturonase
(B) Amylase
(C) Cellulase
(D) Pectinase

25. Which of the following is considered a major benefit of growing insect-resistant transgenic crops?
(A) An increased reliance on synthetic chemical fertilizers
(B) Complete eradication of all native insect species in the agricultural region
(C) Reduced reliance on chemical pesticides
(D) Significantly higher susceptibility to viral plant diseases

26. Arrange the following steps in the correct order for creating a transgenic plant.
1. Insertion of the gene into a suitable vector
2. Isolation of the desired gene
3. Regeneration of the plant via tissue culture
4. Transformation of the plant cell with the recombinant vector

(A) 2, 1, 4, 3
(B) 1, 2, 3, 4
(C) 2, 4, 1, 3
(D) 4, 1, 2, 3

27. What is a primary environmental concern associated with the cultivation of transgenic crops?
(A) They require highly specific synthetic soils to grow.
(B) They produce excessive amounts of oxygen that disrupt local microclimates.
(C) They deplete all nitrogen from the soil within one generation.
(D) The possibility of transgene flow to wild relatives, creating superweeds.

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28. Consider the following statements regarding Bt cotton:
I. It contains genes from a soil bacterium.
II. It requires more frequent insecticide sprays than normal cotton.
III. It is resistant to specific lepidopteran pests.
IV. The toxin becomes active in the alkaline gut of the insect.

Which of the above statements is/are correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and IV

29. The process of fusing protoplasts of two different plant species to create a hybrid (e.g., Pomato) is known as:
(A) Recombinant genetic engineering
(B) Induced mutation breeding
(C) Somatic hybridization
(D) Tissue micropropagation

30. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Agrobacterium tumefaciens is often referred to as a natural genetic engineer of plants.
Reason (R): It naturally transfers a piece of its DNA into the host plant genome to cause crown gall disease.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

of India's Ministry of Environment, Forest and Climate Change. Constituted under the Environment Protection Act, 1986 and rules framed in 1989, GEAC regulates biosafety aspects, environmental impact assessments, and commercial approvals for recombinant DNA organisms across the country.

94. (A) III, IV, II, I
Developing and releasing a GM crop in India follows a structured regulatory process. Research begins with laboratory synthesis and greenhouse testing. Next, the Review Committee on Genetic Manipulation evaluates pre-clinical safety. Upon approval, confined field trials (BRL-I and BRL-II) assess agronomic performance and biosafety. Finally, GEAC grants commercial clearance.

95. (D) Institutional Biosafety Committee (IBSC)
While GEAC oversees environmental releases, institutional monitoring of ongoing recombinant DNA research is managed by the Institutional Biosafety Committee. Established within every institution conducting genetic engineering research, the IBSC enforces containment protocols, evaluates risk assessments, and ensures compliance with national biosafety guidelines to prevent laboratory-acquired infections or containment breaches.

96. (C) Department of Biotechnology (DBT)
The Department of Biotechnology was set up in 1986 under the Ministry of Science and Technology to accelerate biotechnology research, infrastructure, and industrial development across India. DBT promotes cutting-edge research funding, supports human resource development, establishes biotech parks, and formulates regulatory guidelines for bio-pharmaceuticals and agricultural biotechnology.

97. (B) Bio-pharmaceuticals (Biopharma)
The bio-pharmaceutical sector dominates the Indian biotechnology market, generating over half of its total annual revenues. India has established itself as a global hub for producing affordable biosimilars, recombinant vaccines, diagnostics, and therapeutic proteins. High manufacturing standards and strong R&D capabilities have positioned the biopharma industry as the primary economic driver of Indian biotechnology.

98. (D) Biotech Parks and Technology Incubators
To foster innovation and bridge the gap between academic research and commercial market release, the Indian government actively promotes Biotech Parks and Technology Incubators. These specialized facilities provide startups and researchers with state-of-the-art laboratory infrastructure, pilot-scale manufacturing equipment, mentorship, and business support services to accelerate biotechnology commercialisation.

99. (A) Centre for Cellular and Molecular Biology (CCMB), Hyderabad
The Centre for Cellular and Molecular Biology, located in Hyderabad, is an autonomous national research institute operating under the CSIR. CCMB is globally recognized for high-caliber basic research in molecular biology, genomics, cell biology, stem cell research, and infectious diseases, making vital scientific contributions to Indian biological sciences.

100. (A) P-2, Q-4, R-1, S-3
Major biotechnology institutes in India occupy key geographical research hubs. The National Institute of Immunology is in New Delhi, conducting vaccine research. The Centre for Cellular and Molecular Biology operates in Hyderabad. The National Centre for Cell Science is in Pune, while the Central Arid Zone Research Institute is located in Jodhpur.

101. (A) Understanding immune mechanisms and developing novel vaccines
The National Institute of Immunology in New Delhi focuses its research on unraveling fundamental cellular and molecular mechanisms governing the immune system. NII develops novel vaccines, immunodiagnostics, and therapeutic interventions against infectious diseases, cancer, and autoimmune conditions, contributing significantly to advanced immunological and biomedical research in India.

102. (D) Central Arid Zone Research Institute (CAZRI)
Located in Jodhpur, the Central Arid Zone Research Institute plays a central role in agricultural biotechnology for arid regions like Rajasthan. CAZRI conducts research on developing drought-tolerant crop varieties, sustainable desert farming, soil conservation, and stress biology to enhance agricultural

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This process involves scaling up production in bioreactors, conducting safety and efficacy testing, obtaining regulatory clearances, fulfilling biosafety standards, establishing distribution networks, and marketing the product to end consumers successfully.

85. (A) Downstream processing
Downstream processing encompasses all operations following the cell growth and biological synthesis phase in bioprocessing. It includes cellular harvesting, extraction, separation, purification, and final formulation of target biomolecules into marketable biotech drugs or biochemicals. This stage is critical for ensuring drug purity, structural integrity, shelf stability, and strict regulatory compliance.

86. (A) II, IV, III, I
Bringing a novel biotech product to market follows a strict sequential pathway. First, fundamental research and development occurs within laboratory environments. Next, extensive pre-clinical and clinical trials are conducted to verify safety and therapeutic efficacy. Following clinical validation, regulatory bodies review data for approval, enabling large-scale industrial manufacturing and commercial distribution.

87. (B) Strict regulatory safety tests and public acceptance hurdles
A major hurdle in commercializing agricultural biotechnology products involves navigating stringent multi-tier regulatory frameworks and overcoming public skepticism. Developers must undergo years of rigorous environmental impact studies, toxicity testing, and field trials to demonstrate safety. Furthermore, gaining consumer trust regarding genetically modified food safety remains a significant barrier to commercial market adoption.

88. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Regulatory authorities strictly mandate multi-phase clinical trials before approving any recombinant drug for public commercialisation. Clinical trials systematically evaluate therapeutic efficacy, optimal dosing, potential side effects, and long-term toxicity in human populations. Because patient safety and therapeutic benefit must be proven beyond doubt, clinical trials serve as an indispensable regulatory prerequisite.

89. (D) Laminar air flow cabinet
A laminar air flow cabinet is standard laboratory equipment essential for maintaining aseptic conditions in biotechnology and tissue culture work. It continuously blows filtered air through High-Efficiency Particulate Air (HEPA) filters across the workspace, removing airborne microbial contaminants and dust particles, thereby protecting biological samples and cell cultures from contamination during manipulations.

90. (A) Maintain isolation distances or buffer zones around GM fields
To prevent gene flow and accidental cross-pollination between genetically modified crops and surrounding wild relatives or conventional fields, farmers establish physical isolation distances or non-GM buffer zones. These spatial barriers restrict airborne or insect-mediated pollen dispersal, thereby preserving non-GM crop purity and preventing unintended ecological transgene escape into non-target plant populations.

91. (B) Human reproductive cloning is strictly prohibited
International biosafety conventions and national bioethics regulatory frameworks universally prohibit human reproductive cloning. This global ban stems from severe ethical, physiological, and safety concerns, including high rates of developmental abnormalities observed in cloned mammals. In contrast, limited therapeutic cloning research targeting stem cell generation for medical treatment remains regulated under strict oversight.

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92. (B) Genetic Engineering Appraisal Committee (GEAC)
In India, the Genetic Engineering Appraisal Committee is the statutory apex body responsible for evaluating activities involving the large-scale use, research, and environmental release of genetically modified organisms. Operating under environmental protection legislation, GEAC reviews field trial data and assesses biosafety implications before approving the commercial cultivation or environmental release of GMOs.

93. (A) Ministry of Environment, Forest and Climate Change
The Genetic Engineering Appraisal Committee functions under the administrative control

112. (A) P-3, Q-2, R-1, S-4
Biostimulation involves adding nutrients to stimulate native soil microbes, whereas bioaugmentation adds specialized engineered microbes directly to contaminated sites. Phytoremediation utilizes living plants to extract or degrade environmental contaminants, and bioleaching employs acidophilic microorganisms to extract valuable metals from low-grade mineral ores efficiently through biological oxidation processes.

113. (B) Incinerating chemical waste in industrial furnaces
Bioremediation strictly involves biological processes driven by living organisms like bacteria, fungi, or plants to degrade environmental contaminants. Incinerating chemical waste in industrial furnaces is a thermal chemical disposal process rather than a biological one. In contrast, oil spill degradation, phytoremediation of heavy metals, and organic composting represent authentic bioremediation practices.

114. (D) CRISPR-Cas9
CRISPR-Cas9 is a revolutionary gene-editing technology adapted from a bacterial adaptive immune system. It uses a guide RNA sequence to direct the Cas9 endonuclease enzyme to double-stranded DNA target sites with extreme precision. This molecular mechanism enables researchers to edit, delete, or insert specific genomic sequences accurately across various organisms.

115. (A) Tailoring treatments based on an individual's unique genetic profile
Personalized medicine, or precision medicine, transforms healthcare by customizing medical therapies according to an individual patient's unique genomic background. By analyzing genomic data, clinicians predict disease susceptibility, determine targeted drug responses, and optimize therapeutic dosages specifically tailored to the patient, minimizing adverse drug reactions and improving overall clinical outcomes significantly.

116. (C) DNA (Deoxyribonucleic Acid)
DNA data storage is an emerging bio-computing technology that encodes digital binary data (zeros and ones) into nucleotide base sequences (A, C, G, T). DNA offers unmatched data storage density and extreme longevity compared to conventional electronic media. A single gram of synthetic DNA can theoretically store petabytes of digital information for thousands of years.

117. (A) Cultured meat or lab-grown meat
Cultured meat, also called lab-grown meat, is synthesized through cellular agriculture by harvesting stem cells from animals and expanding them in bioreactors with nutrient media. The cells differentiate into genuine muscle and fat tissue without animal slaughter. Cultured meat offers a sustainable, ethical alternative to traditional livestock farming, reducing greenhouse gas emissions.

118. (A) P-2, Q-1, R-4, S-3
Advanced biotechnology concepts address complex scientific frontiers. CRISPR-Cas9 enables precise target genome editing. Gene drives biasedly propagate engineered genetic traits rapidly through wild populations. Synthetic biology designs and constructs artificial biological components and systems, while DNA computing utilizes biological molecules for ultra-dense data storage and massive parallel computational processing.

119. (B) De-extinction (Resurrection biology)
De-extinction, or resurrection biology, is a futuristic application combining ancient DNA sequencing, gene editing, and cloning technologies to recreate extinct species. By editing genomic sequences of closely related living species to mirror preserved DNA from extinct organisms like the Woolly Mammoth and inserting them into surrogate mothers, scientists aim to restore lost species and ecosystems.

120. (C) Humans will stop aging and achieve biological immortality in two years
Biological aging is a complex biological process influenced by cellular senescence, DNA damage, metabolic changes, and telomere shortening. While biotechnology advances gene therapy, regenerative stem cells, and targeted disease treatments, achieving complete biological immortality within two years is scientifically unrealistic and biologically improbable given current biological understanding and technical limitations.

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productivity and ecological resilience under hyper-arid climatic conditions.

103. (B) Significant reduction in chemical insecticide usage
A primary environmental benefit of cultivating Bt cotton is the dramatic reduction in synthetic chemical insecticide applications. Because Bt cotton plants endogenously produce insecticidal cry proteins targeting bollworm pests, farmers rely far less on chemical sprays. This reduces chemical runoff into water bodies, lowers soil contamination, and preserves beneficial non-target insect populations.

104. (C) GM seeds are proprietary, costly, and repurchased each season
A notable socio-economic limitation of agricultural biotechnology is that GM seeds are patented proprietary products owned by biotech corporations. These seeds are expensive and often contain intellectual property restrictions preventing seed saving. Consequently, resource-limited farmers must buy fresh, costly seed stocks each planting season, increasing agricultural input expenses and financial vulnerability.

105. (D) Target pests may evolve resistance to GM toxins over time
A major biological risk associated with widespread, continuous cultivation of insect-resistant GM crops is the emergence of pest resistance. Continuous exposure to insecticidal endotoxins imposes selective pressure on target pest populations, leading to the natural selection and survival of resistant insect strains. Managing this requires planting non-GM refuge crops to delay resistance development.

106. (A) I and II only
Recombinant human proteins match natural human structures, avoiding allergic reactions common with non-human animal proteins. In gene therapy, viral vector immunogenicity remains a clinical challenge as vectors can provoke inflammatory host immune responses. Statement III is false because unchecked transgene escape or invasive transformed species can disrupt natural ecosystems and biodiversity.

107. (B) Environmental Biotechnology
Environmental Biotechnology is the specialized branch of biotechnology that applies living organisms, biological systems, or enzymes to monitor, remediate, and manage environmental pollution. It encompasses processes such as biological wastewater treatment, hazardous waste degradation, air pollution biofiltration, and soil bioremediation, supporting ecological conservation and sustainable waste management strategies.

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108. (B) Bioremediation
Bioremediation is a green technology process that utilizes naturally occurring or genetically engineered microorganisms like bacteria and fungi to degrade, transform, or detoxify environmental contaminants into harmless compounds like water and carbon dioxide. Bioremediation effectively cleans up soil, groundwater, industrial effluents, and crude oil spills without requiring harsh chemical treatments.

109. (A) Pseudomonas putida
The oil-eating genetically engineered strain of Pseudomonas putida, dubbed the superbug, was created by scientist Ananda Chakrabarty. By combining multiple catabolic plasmids into a single bacterial cell, this engineered strain gained the ability to metabolize various crude oil hydrocarbons rapidly, providing a groundbreaking bio-based solution for cleaning up marine oil spills.

110. (C) Living plants
Phytoremediation is an eco-friendly environmental biotechnology technique that utilizes green living plants to extract, accumulate, immobilize, or degrade hazardous pollutants present in contaminated soil and water. Specific hyperaccumulating plant species absorb heavy metals, organic solvents, or agricultural pesticides through root systems, effectively decontaminating polluted landscapes naturally over time.

111. (D) Biogas (predominantly methane)
Methanogenic bacteria, such as Methanobacterium, play a fundamental role in waste management by decomposing organic waste under strict anaerobic conditions. Through anaerobic digestion of agricultural residue, sewage, and livestock manure, these anaerobic microbes synthesize biogas, a clean renewable fuel composed primarily of methane and carbon dioxide, simultaneously producing nutrient-rich organic bio-slurry.

(B) A transgenic line
(C) A pure line
(D) A somaclonal line

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Bagging is an essential step in artificial hybridization.
Reason (R): Bagging protects the emasculated flower from contamination by unwanted pollen grains.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

11. Which two crops were primarily the focus during the initial phase of the Green Revolution in India?
(A) Wheat and Maize
(B) Rice and Cotton
(C) Pearl Millet and Gram
(D) Wheat and Rice

12. Sonalika and Kalyan Sona are well-known high-yielding varieties of which crop?
(A) Rice
(B) Wheat
(C) Maize
(D) Sugarcane

13. How is a Genetically Modified (GM) crop primarily different from a traditionally bred crop?
(A) A GM crop is cultivated entirely without requiring natural rainfall or irrigation water.
(B) A GM crop is produced exclusively by cross-pollinating two distinct wild plant species.
(C) A GM crop contains specific foreign genes inserted into its genome.
(D) A GM crop is rendered completely immune to all biotic and abiotic environmental stresses.

14. What does the "Bt" in Bt cotton stand for?
(A) Biotechnology
(B) Botanical trait
(C) Bacterial technology
(D) Bacillus thuringiensis

15. The Bt toxin produced by Bt cotton provides resistance against which of the following?
(A) Cotton bollworms
(B) Fungal plant diseases
(C) Pathogenic viral infections
(D) Soil-borne nematodes

16. Why does the Bt toxin not kill the Bacillus thuringiensis bacterium itself?
(A) The bacterium has an antitoxin gene.
(B) The toxin exists as an inactive protoxin within the bacterium.
(C) The bacterium secretes the toxin out of its cell instantly.
(D) The toxin requires an acidic pH to become active, which the bacterium lacks.

17. Which of the following statements about Genetically Modified (GM) crops is incorrect?
(A) They can be tailored to have enhanced nutritional value.
(B) They are created without altering the natural DNA sequence of the plant.
(C) They are generally more tolerant to abiotic stresses than conventional crops.
(D) They can help reduce reliance on chemical pesticides.

18. Match the Genetically Modified crops in List I with their key traits in List II.
List I: (Genetically Modified Crops)
P. Bt Cotton
Q. Golden Rice
R. Flavr Savr Tomato
S. Roundup Ready Soybeans
List II: (Key Traits)
1. Herbicide tolerance
2. Insect resistance
3. Delayed ripening
4. Enhanced Vitamin A
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-1, Q-3, R-2, S-4
(D) P-2, Q-1, R-4, S-3

19. The specific genes that code for the insecticidal proteins in Bacillus thuringiensis are known as:
(A) nif genes
(B) lac genes
(C) cry genes
(D) onc genes

20. An organism that has an altered genome through the insertion of a foreign gene is scientifically termed as:
(A) A mutagenic agent

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CHAPTER 16
Plant Varieties and Transgenic Organisms

1. What is the primary objective of plant breeding?
(A) To study and document the evolutionary history and natural genetic variation of wild plants
(B) To produce crop varieties with desired traits like high yield and disease resistance
(C) To strictly conserve traditional agricultural farming practices without modifying crop genetic traits
(D) To eliminate uncultivated wild plant species from natural agricultural ecosystems

2. Who is known as the Father of the Green Revolution in the world?
(A) Norman E. Borlaug
(B) M.S. Swaminathan
(C) H.G. Khorana
(D) Gregor Mendel

3. Which of the following is the oldest traditional method of plant breeding?
(A) Genetic engineering
(B) Mutation breeding
(C) Selection
(D) Somatic hybridization

4. In traditional plant breeding, what is the purpose of emasculation?
(A) To actively promote and facilitate self-pollination within a bisexual floral structure
(B) To safeguard the developing flower bud from potential damage by insect pests
(C) To enhance the overall nutritional value and protein content of the harvested seed
(D) To prevent self-pollination by removing anthers from bisexual flowers

5. The phenomenon where a hybrid offspring exhibits traits superior to both its parents is known as:
(A) Inbreeding depression
(B) Pure line selection
(C) Heterosis
(D) Polyploidy

6. Match the scientists in List I with their key contributions in List II.

List I: (Scientists)
P. Norman Borlaug
Q. M.S. Swaminathan
R. Ingo Potrykus
S. Gregor Mendel
List II: (Contributions)
1. Father of Genetics
2. Golden Rice
3. Indian Green Revolution
4. Global Green Revolution
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-2, R-3, S-4

7. Select the correct order of the fundamental steps involved in breeding a new plant variety.
(A) Selection of parents → Collection of variability → Cross-hybridization → Testing and release
(B) Collection of variability → Selection of parents → Cross-hybridization → Testing and release
(C) Cross-hybridization → Collection of variability → Selection of parents → Testing and release
(D) Testing and release → Selection of parents → Cross-hybridization → Collection of variability

8. Consider the following characteristics of crop varieties introduced during the Green Revolution:
I. Semi-dwarf stature
II. High responsiveness to fertilizers
III. Low water requirement
IV. High grain yield
Which of the above statements are correct?
(A) I, II, and IV are correct
(B) II, III, and IV are correct
(C) I, III, and IV are correct
(D) I, II, and III are correct

9. A population of plants that is homozygous and generated through continuous self-pollination is called:
(A) A hybrid line

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31. The set of regulations and practices intended to ensure that biotechnology research and products do not pose risks to human health or the environment is termed:
(A) Biosafety
(B) Biopiracy
(C) Bioethics
(D) Bioprospecting

32. Which international agreement specifically addresses the safe handling, transport, and use of living modified organisms (LMOs)?
(A) Kyoto Protocol
(B) Cartagena Protocol
(C) Montreal Protocol
(D) Paris Agreement

33. Which regulatory body in India is responsible for granting approval for the commercial cultivation of GM crops?
(A) Indian Council of Agricultural Research (ICAR)
(B) Genetic Engineering Appraisal Committee (GEAC)
(C) Ministry of Agriculture
(D) Food Safety and Standards Authority of India (FSSAI)

34. In seed banks, plant genetic resources are often preserved at ultra-low temperatures using liquid nitrogen. What is this temperature?
(A) -196 degrees C
(B) -4 degrees C
(C) -20 degrees C
(D) -70 degrees C

35. What is the primary purpose of establishing gene banks and seed banks?
(A) To strictly facilitate international commercial trade of agricultural seeds for maximum profit
(B) To efficiently distribute synthetic chemical fertilizers and pesticides to local farmers
(C) To conserve plant genetic diversity for future crop breeding
(D) To systematically replace and eradicate older indigenous landraces of crop species

36. Match the conservation strategies in List I with their appropriate descriptions in List II.
List I: (Conservation Strategies)
P. In-situ conservation
Q. Ex-situ conservation
R. Cryopreservation
S. Seed bank
List II: (Descriptions)
1. Storage facility for preserving seeds over long periods
2. Conservation of species in their natural habitats
3. Preservation of biological material at -196 C
4. Conservation of species outside their natural habitats
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-4, R-2, S-1

37. Which of the following is considered a major economic disadvantage of using hybrid seeds for farmers?
(A) Hybrid crop plants yield significantly lower economic returns than traditional wild varieties.
(B) Hybrid plants mature extremely slowly compared to unselected natural wild plant species.
(C) Loss of hybrid vigor in offspring forces annual seed repurchasing.
(D) They demand exclusively certified organic farming techniques and inputs to produce yield.

38. A controversial genetic technology designed to produce sterile seeds so that farmers must purchase new seeds every year is commonly known as:
(A) Antisense technology
(B) Terminator technology
(C) Recombinant technology
(D) Gene therapy

39. Where is the headquarters of the National Bureau of Plant Genetic Resources (NBPGR) located in India?
(A) Hyderabad
(B) Jodhpur
(C) Lucknow
(D) New Delhi

40. In plant breeding, which term describes plants that produce offspring identical to themselves when self-pollinated?
(A) True-breeding lines
(B) Complex heterozygous lines
(C) Superior hybrid lines
(D) Variable segregating lines

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(B) Pune
(C) Bangalore
(D) Chennai

64. Botanical gardens, zoological parks, and seed banks represent which type of biodiversity conservation?
(A) In-situ conservation
(B) Ex-situ conservation
(C) Cryogenic preservation exclusively
(D) Natural habitat restoration

65. Match the agricultural research institutions in List I with their locations in List II.
List I: (Research Institutions)
P. CAZRI
Q. IARI
R. NDRI (National Dairy Research Institute)
S. AFRI (Arid Forest Research Institute)
List II: (Locations)
1. Karnal
2. Jodhpur
3. New Delhi
4. Jodhpur
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-1, Q-2, R-4, S-3

66. A notable ecological controversy surrounding Bt corn involved fears that its wind-blown pollen was toxic to the larvae of which non-target insect?
(A) Monarch butterfly
(B) Honey bee
(C) Ladybird beetle
(D) Silkworm

67. Select the correct sequence of steps involved in the Polymerase Chain Reaction (PCR), a key technique used in identifying plant genes and molecular markers.
(A) Annealing → Denaturation → Extension
(B) Extension → Denaturation → Annealing
(C) Denaturation → Annealing → Extension
(D) Denaturation → Extension → Annealing

68. What is the fundamental difference between traditional plant breeding and genetic modification (GM)?
(A) Traditional breeding relies strictly on single-gene transfer methods, whereas genetic modification always involves crossing whole plant genomes.
(B) Traditional crop breeding utilizes bacterial vectors for gene delivery, while genetic modification relies exclusively on natural floral pollination.
(C) There is no fundamental difference between the two approaches; both rely entirely on ionizing radiation to induce random genomic mutations.
(D) Traditional breeding mixes thousands of genes; GM introduces a specific gene.

69. The geographical regions where a crop species was first domesticated and displays its maximum genetic diversity are known as:
(A) Biosphere reserves
(B) Hotspots
(C) Vavilov Centers of Origin
(D) Sacred groves

70. The gradual loss of genetic diversity in agricultural crops, often due to the widespread adoption of a few high-yielding varieties, is referred to as:
(A) Genetic drift
(B) Genetic erosion
(C) Genetic mapping
(D) Gene editing

71. In agricultural biotechnology, DNA sequences that are located near genes of interest and inherited alongside them are used to track specific traits. What are these known as?
(A) Promoters
(B) Restriction enzymes
(C) Stop codons
(D) Molecular markers

72. What is a primary advantage of Marker-Assisted Selection (MAS) in plant breeding?
(A) It identifies desired traits at the seedling stage using DNA markers.
(B) It completely eliminates the requirement for irrigation water or synthetic fertilizers throughout the crop lifecycle.
(C) It instantly transforms any non-leguminous crop into an efficient atmospheric nitrogen-fixing organism.
(D) It causes the crop plant to bioluminesce in the dark, effectively deterring all nocturnal insect pests.

73. The CRISPR-Cas9 system has emerged as a revolutionary technology in plant biotechnology. What is its primary function?
(A) Mass production of synthetic fertilizers

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52. The milk produced by the transgenic cow Rosie was enriched with which human protein?
(A) Human insulin
(B) Human growth hormone
(C) Alpha-1 antitrypsin
(D) Human alpha-lactalbumin

53. Transgenic mice are extensively developed and used for which of the following primary purposes?
(A) To synthesize and harvest massive commercial quantities of milk
(B) To serve as domestic household pets possessing unique coat colors
(C) To test vaccine safety prior to human use
(D) To effectively eliminate and eradicate wild rodent mouse populations

54. The transgenic human protein Alpha-1 antitrypsin is utilized primarily to treat which medical condition?
(A) Diabetes mellitus
(B) Emphysema
(C) Cystic fibrosis
(D) Hemophilia

55. What correctly defines a transgenic animal?
(A) An animal that has inhabited multiple distinct geographical ecological habitats over time.
(B) An animal that results from an interspecific cross between two distinct species, such as a mule.
(C) An animal that has naturally acquired a beneficial spontaneous chromosomal mutation.
(D) An animal expressing a foreign gene inserted into its genome.

56. Consider the following statements regarding the main applications of transgenic animals in science and medicine:
I. Study of normal physiology and development
II. Production of biological products (like medicines)
III. Testing chemical safety and toxicity
IV. Increasing the population of endangered species directly
Which of the above statements is/are correct?
(A) I, II, and III are correct
(B) II, III, and IV are correct
(C) I, III, and IV are correct
(D) I, II, and IV are correct

57. The use of bio-resources by multinational companies without proper authorization from the countries and people concerned is known as:
(A) Bioethics
(B) Biosafety
(C) Biopiracy
(D) Bioremediation

58. The first clinical gene therapy was given in 1990 to a 4-year-old girl to treat a deficiency of which enzyme?
(A) Adenosine deaminase (ADA)
(B) Tyrosine kinase
(C) DNA polymerase
(D) Phenylalanine hydroxylase

59. In the context of the regulatory framework for GMOs in India, what does GEAC stand for?
(A) Genetic Engineering Approval Council
(B) Genome Evaluation and Application Centre
(C) Genetic Enhancement and Agricultural Committee
(D) Genetic Engineering Appraisal Committee

60. Which Indian legislative act was specifically amended to include issues related to biopiracy and the patenting of indigenous biological resources?
(A) Wildlife Protection Act, 1972
(B) Indian Patents Act, 1970
(C) Environment Protection Act, 1986
(D) Biological Diversity Act, 2002

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61. A major debate regarding the environmental impact of GM crops involves the possibility that herbicide-resistant genes could transfer to related wild plant species. What are such resultant wild plants colloquially called?
(A) Epiphytes
(B) Biopesticides
(C) Superweeds
(D) Transgenic clones

62. Which premier national organization in India coordinates, guides, and manages research and education in agriculture?
(A) AIIMS
(B) DRDO
(C) ISRO
(D) ICAR

63. The Indian Agricultural Research Institute (IARI), known for its pioneering work during the Green Revolution, is situated in:
(A) New Delhi

(A) Dry ice
(B) Liquid oxygen
(C) Solid carbon dioxide
(D) Liquid nitrogen

104. Which research institute based in Jodhpur focuses on increasing the productivity and conserving the biodiversity of arid forest ecosystems?
(A) Arid Forest Research Institute (AFRI)
(B) Central Arid Zone Research Institute (CAZRI)
(C) Indian Institute of Forest Management (IIFM)
(D) Forest Survey of India (FSI)

105. For long-term viability, modern seed banks typically store seeds under which environmental conditions?
(A) High temperature and high moisture
(B) Low temperature and high moisture
(C) Low temperature and low moisture
(D) Room temperature and moderate moisture

106. In plant tissue culture, embryos that develop directly from somatic (vegetative) cells rather than through sexual fertilization are termed:
(A) Somatic embryos
(B) Zygotic embryos
(C) Parthenocarpic embryos
(D) Apomictic embryos

107. Consider the following biodiversity conservation methods:
I. National Parks
II. Botanical Gardens
III. Seed Banks
IV. Biosphere Reserves
V. Cryopreservation facilities
Which of the above options represent methods of Ex-situ conservation?
(A) I, II, and III
(B) II, III, and V
(C) I, IV, and V
(D) III, IV, and V

108. Besides increasing yield and disease resistance, modern plant breeding heavily emphasizes biofortification. What is the primary goal of biofortification?
(A) To make the plant resistant to all known herbicides
(B) To change the color of the flowers for ornamental purposes
(C) To reduce the height of the plant
(D) To improve the nutritional quality of the crops

109. The high-yielding semi-dwarf wheat varieties brought to India in 1963, which sparked the Green Revolution, were developed in which country?
(A) USA
(B) Japan
(C) Mexico
(D) Australia

110. In the year 2000, specific maize hybrids were developed in India as part of biofortification efforts. These hybrids had twice the amount of which two essential amino acids compared to existing hybrids?
(A) Methionine and Cysteine
(B) Valine and Leucine
(C) Arginine and Histidine
(D) Lysine and Tryptophan

111. The protein encoded by the cry gene in Bacillus thuringiensis is toxic to insects because it damages their:
(A) Midgut epithelial cells
(B) Nervous system
(C) Respiratory spiracles
(D) Reproductive organs

112. A patent granted by the government to an inventor for a biological entity, process, or product is specifically known as a:
(A) Trademark
(B) Biopatent
(C) Copyright
(D) Bio-license

113. In 1997, a major controversy regarding biopiracy occurred when an American company successfully obtained a US patent for which traditionally Indian crop variety?
(A) Golden Rice
(B) Basmati Rice
(C) Sharbati Sonora Wheat
(D) Bt Cotton

114. Which of the following best describes an ethical issue raised by critics concerning the creation of transgenic animals and plants?
(A) Mixing genes across unrelated species violates natural barriers.
(B) Transgenic crop varieties consistently yield lower economic harvests than traditional lines under all conditions.

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(B) Cryopreservation of seeds
(C) Targeted gene editing
(D) Inducing random mutations through radiation

74. In the CRISPR-Cas9 technology, the Cas9 protein acts fundamentally as:
(A) A molecular scissor cutting DNA at specific sites
(B) An essential joining ligase enzyme that seals broken single-stranded DNA fragments together
(C) A specialized biological vector responsible for transporting foreign genes across rigid cell walls
(D) A primary transcription polymerase enzyme that rapidly synthesizes single-stranded messenger RNA

75. How does a gene-edited crop (using CRISPR) generally differ from a classic transgenic crop (like Bt cotton) under current scientific definitions?
(A) Gene-edited crops consistently contain functional bacterial plasmid DNA sequences, whereas transgenic crops never retain foreign bacterial vector material.
(B) Gene-edited crop varieties are exclusively resistant to environmental drought, whereas transgenic crop lines are engineered only for insect pest resistance.
(C) Gene-edited plants are rendered completely sterile and are incapable of producing viable seeds for subsequent planting cycles under any condition.
(D) Gene editing modifies existing DNA without foreign genes; transgenics insert foreign DNA.

76. The widespread adoption of improved, high-yielding crop varieties in India has had which direct socio-economic impact?
(A) Total and immediate elimination of the entire rural agricultural workforce across the country
(B) Higher yields improving food security and farmer incomes
(C) Complete destruction and collapse of all international export markets for indigenous Indian crops
(D) Complete legal banning and immediate withdrawal of all government agricultural input subsidies

77. Transgenic crops can contribute to global food security in the future primarily by:
(A) Ensuring that all major staple agricultural crops possess identical taste profiles across global markets
(B) Substantially increasing post-harvest crop spoilage and storage losses during international transport
(C) Developing resilient crops requiring fewer chemical inputs
(D) Requiring vastly larger land surface areas to cultivate and produce equivalent amounts of human food

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78. Consider the following statements regarding the CRISPR gene-editing technology:
I. It is derived from a bacterial defense system against viruses.
II. It allows for highly precise modifications in the genome.
III. It utilizes guide RNA to locate the target DNA sequence.
IV. It only works on animal cells, never on plant cells.
Which of the above statements is/are correct?
(A) I, II, and III are correct
(B) II, III, and IV are correct
(C) I, II, and IV are correct
(D) I, III, and IV are correct

79. Match the tools of biotechnology in List I with their standard functions in List II.
List I: (Tools of Biotechnology)
P. Restriction Endonuclease
Q. DNA Ligase
R. Plasmid
S. Bioreactor
List II: (Functions)
1. Acts as a cloning vector
2. Large vessel for culturing host cells on an industrial scale
3. Joins fragments of DNA together
4. Cuts DNA at specific recognition sites
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-1, R-3, S-2
(D) P-1, Q-2, R-3, S-4

80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cultivation of transgenic Bt crops can significantly reduce environmental pollution caused by agriculture.

41. The agricultural strategy of breeding crops specifically to increase their nutritional value (vitamins, minerals) is called:
(A) Bioremediation
(B) Biomagnification
(C) Biofortification
(D) Biosafety

42. Which morphological feature is a characteristic adaptation of drought-tolerant plant varieties in arid regions?
(A) Thick cuticle and deep root system
(B) Large, broad, thin leaves with high stomatal density
(C) Extensive shallow and widespread fibrous root network
(D) Complete absence of functional leaf stomatal pores

43. Plants that are naturally adapted to grow in high-salinity soils and serve as genetic resources for breeding salinity-tolerant crops are called:
(A) Hydrophytes
(B) Xerophytes
(C) Mesophytes
(D) Halophytes

44. The Central Arid Zone Research Institute (CAZRI), which plays a vital role in developing crop varieties for arid climates, is located in:
(A) Jaipur
(B) Jodhpur
(C) Bikaner
(D) Jaisalmer

45. 'Himgiri' is an improved variety of wheat developed through traditional breeding. It is highly resistant to which disease?
(A) Bacterial blight
(B) Tobacco mosaic virus
(C) Leaf and stripe rust
(D) White rust

46. 'Pusa Swarnim' is a disease-resistant variety of which crop?
(A) Rice
(B) Cowpea
(C) Chilli
(D) Brassica (Mustard)

47. Match the crop varieties in List I with their corresponding resistance in List II.
List I: (Crop Varieties)
P. Pusa Shubhra
Q. Pusa Sadabahar
R. Pusa Komal
S. Pusa Snowball K-1
List II: (Disease Resistance)
1. Bacterial blight
2. Chilli mosaic virus
3. Black rot
4. Leaf curl
(A) P-3, Q-2, R-1, S-3
(B) P-1, Q-2, R-3, S-3
(C) P-2, Q-3, R-1, S-3
(D) P-3, Q-1, R-2, S-3

48. Treating seeds with chemicals or gamma radiation to induce sudden genetic changes for plant breeding is known as:
(A) Genetic engineering
(B) Mutation breeding
(C) Polyploidy breeding
(D) Hybridization

49. What makes 'Golden Rice' nutritionally superior to ordinary white rice?
(A) Significantly elevated levels of total crude protein content
(B) Rich in beta-carotene (Pro-Vitamin A)
(C) Abundant amounts of essential dietary Vitamin C ascorbic acid
(D) Significantly enriched essential mineral iron bio-content

50. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Golden Rice was developed to combat widespread Vitamin A deficiency in developing nations.
Reason (R): Severe Vitamin A deficiency can lead to night blindness and increased susceptibility to infections.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

51. What was the name of the first transgenic cow, produced in 1997, that generated protein-enriched milk?
(A) Dolly
(B) Polly
(C) Rosie
(D) Tracy

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92. Which specific nematode infects the roots of tobacco plants, causing a significant reduction in yield, prompting the development of transgenic resistant tobacco?
(A) Ascaris lumbricoides
(B) Meloidogyne incognita
(C) Wuchereria bancrofti
(D) Caenorhabditis elegans

93. To create tobacco plants resistant to root-knot nematodes, scientists utilized a novel strategy based on the process of:
(A) Polymerase chain reaction (PCR)
(B) Somatic cell nuclear transfer
(C) RNA interference (RNAi)
(D) Mutation breeding

94. The mechanism of RNA interference (RNAi) provides cellular defense by silencing which specific molecule of the targeted parasite?
(A) Specific DNA sequences
(B) Ribosomal RNA (rRNA)
(C) Transfer RNA (tRNA)
(D) Specific mRNA (messenger RNA)

95. In nature, Agrobacterium tumefaciens infects dicot plants and causes the formation of tumors. What are these plant tumors called?
(A) Crown galls
(B) Root nodules
(C) Leaf spots
(D) Blights

96. What are plasmids, which are widely used as vectors in genetic engineering?
(A) Linear genomic chromosomes located within the defined membrane-bound bacterial nuclear region
(B) Extra-chromosomal circular DNA in bacteria
(C) Plant-pathogenic viral particles that naturally infect eukaryotic vegetative plant host cells
(D) Specialized catalytic protein enzymes responsible for cleaving double-stranded host cell DNA

97. Match the transgenic crop/organism in List I with its relevant characteristic/technology in List II.
List I: (Transgenic Crop/Organism)
P. Transgenic Tobacco
Q. Bt Cotton
R. Golden Rice
S. Flavr Savr Tomato
List II: (Characteristic/Technology)
1. RNA interference against nematodes
2. Bacillus thuringiensis cry gene
3. Beta-carotene enrichment
4. Delayed ripening via enzyme silencing
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-1, Q-3, R-2, S-4
(D) P-4, Q-2, R-3, S-1

98. Which two scientists are credited with the creation of Golden Rice?
(A) Ingo Potrykus and Peter Beyer
(B) Watson and Crick
(C) Norman Borlaug and M.S. Swaminathan
(D) Boyer and Cohen

99. Scientists are researching the development of transgenic plants (like potatoes or bananas) that express antigens of specific pathogens. What is the intended use of these plants?
(A) As natural biopesticides
(B) To produce industrial enzymes
(C) As edible vaccines for humans
(D) To increase the shelf life of the fruit

100. All of the following are generally considered benefits of genetically modified (GM) crops, EXCEPT:
(A) Increased tolerance to abiotic stresses (cold, drought, salt)
(B) Enhanced nutritional value of food
(C) Reduced post-harvest losses
(D) Increased reliance on chemical pesticides

101. Which drought-resistant cereal crop is highly prominent in the arid agricultural landscape of Rajasthan?
(A) Paddy (Rice)
(B) Sugarcane
(C) Bajra (Pearl Millet)
(D) Jute

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102. Which state tree of Rajasthan is renowned for its drought tolerance and is a critical component of traditional agroforestry in the Thar desert?
(A) Teak (Tectona grandis)
(B) Khejri (Prosopis cineraria)
(C) Neem (Azadirachta indica)
(D) Sal (Shorea robusta)

103. Cryopreservation is a highly effective technique for the long-term storage of plant germplasm. Which substance is primarily used to achieve the ultra-low temperatures required?

ANSWERS

1. (B) To produce crop varieties with desired traits like high yield and disease resistance
Plant breeding focuses on purposeful manipulation of plant species to create desired genotypes and phenotypes for human use. By combining genetic variation and selection techniques, breeders systematically develop crop varieties possessing enhanced traits such as higher yield potential, improved pest and disease resistance, environmental stress tolerance, and superior nutritional quality for agricultural production.

2. (A) Norman E. Borlaug
Norman Ernest Borlaug was an American agronomist who led initiative efforts globally to increase agricultural productivity. By developing semi-dwarf, high-yielding, disease-resistant wheat varieties and implementing modern management practices, he spearheaded the global Green Revolution. His contributions saved over a billion people from starvation and earned him the Nobel Peace Prize in 1970.

3. (C) Selection
Selection is the oldest and basic method of plant breeding used since the domestication of plants. It involves identifying and preserving desirable plant phenotypes from a mixed population while discarding inferior ones. Early agriculturalists practiced mass selection by saving seeds from superior individual plants for subsequent planting cycles, laying the foundation for modern crop improvement practices.

4. (D) To prevent self-pollination by removing anthers from bisexual flowers
Emasculation involves removing immature, pollen-bearing anthers from bisexual flower buds before shedding pollen, without damaging female reproductive organs. This critical step in artificial hybridization prevents self-pollination in hermaphrodite flowers. Once emasculated, flowers are protected from unwanted foreign pollen until designated pollen from a selected male parent is manually applied to achieve controlled cross-pollination.

5. (C) Heterosis
Heterosis, commonly called hybrid vigor, describes the phenomenon where offspring from genetically diverse parents display superior phenotypic traits compared to either parent. These improved attributes typically include accelerated growth rates, increased biomass, enhanced grain yields, greater disease resistance, and higher environmental stress tolerance. Hybrid vigor is widely exploited in agricultural seed production to boost overall farm productivity.

6. (A) P-4, Q-3, R-2, S-1
Norman Borlaug led global Green Revolution initiatives, developing high-yielding semi-dwarf wheat strains. M.S. Swaminathan spearheaded India's Green Revolution through successful introduction and adaptation of dwarf wheat varieties. Ingo Potrykus co-developed biofortified Golden Rice genetically engineered to produce beta-carotene. Gregor Mendel established fundamental laws of inheritance through experimental pea plant breeding, earning recognition as the Father of Genetics.

7. (B) Collection of variability → Selection of parents → Cross-hybridization → Testing and release
Plant breeding follows a systematic sequential process. First, germplasm collection gathers all existing genetic variability of a crop species. Next, parents showing superior target traits are selected from germplasm accessions. Controlled cross-hybridization between chosen parents combines desired traits in hybrid progeny. Finally, superior recombinant lineages undergo evaluation, testing across multi-location trials, commercial registration, and release to farmers.

8. (A) I, II, and IV are correct
High-yielding crop varieties developed during the Green Revolution possessed semi-dwarf stature, which prevented stem lodging under heavy grain loads. They exhibited high responsiveness to chemical nitrogenous fertilizers, resulting in substantially increased grain yield. However, these crop cultivars required abundant and controlled irrigation supplies rather than low water inputs to achieve their maximum

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(C) Mass production of transgenic organisms inevitably causes severe destruction of pristine natural forest ecosystems.
(D) Recombinant transgenic technology can exclusively be carried out using high-risk human and animal pathogens.

115. The Genetic Engineering Appraisal Committee (GEAC), which regulates GM crops in India, functions under which Union Ministry?
(A) Ministry of Agriculture and Farmers Welfare
(B) Ministry of Science and Technology
(C) Ministry of Environment, Forest and Climate Change
(D) Ministry of Health and Family Welfare

116. In molecular biology and plant breeding, the term RFLP is a widely used molecular marker. What does RFLP stand for?
(A) Random Fragment Length Polymerase
(B) Rapid Fluorescent Locus Primer
(C) Recombinant Factor Linking Protein
(D) Restriction Fragment Length Polymorphism

117. An essential requirement for successful plant tissue culture is the complete sterilization of the culture media and vessels to prevent microbial growth. Which equipment is standardly used for this purpose?
(A) Centrifuge
(B) Spectrophotometer
(C) Autoclave
(D) PCR machine

118. Match the biofortified crop developed by IARI in List I with its enriched nutrient in List II.
List I: (Biofortified Crop)
P. Iron-fortified
Q. Vitamin A enriched
R. Vitamin C enriched
S. Protein enriched
List II: (Enriched Nutrient)
1. Spinach and Bathua
2. Carrots and Pumpkin
3. Bitter gourd and Mustard
4. Broad bean and French bean
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-1, Q-3, R-2, S-4
(D) P-3, Q-2, R-1, S-4

119. Which of the following is considered a major long-term future prospect of plant biotechnology that would drastically reduce the need for synthetic urea fertilizers?
(A) Developing engineered agricultural crops that possess absolute immunity against all known plant viruses
(B) Creating synthetic seed lines that remain viable indefinitely without expiring or losing germination capacity
(C) Modifying photosynthetic pathways to allow crops to grow and produce yield exclusively in complete darkness
(D) Engineering non-leguminous crops to fix atmospheric nitrogen directly

120. When breeding improved plant varieties, scientists often target resistance against abiotic stresses. Which of the following is an example of an abiotic stress?
(A) Prolonged drought
(B) Fungal infection
(C) Nematode infestation
(D) Insect grazing

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Reason (R): Bt crops have an inbuilt mechanism of insect resistance, drastically reducing the farmer's reliance on chemical insecticide sprays.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

81. In artificial hybridization, why is a flower covered with a butter paper bag (bagging) after emasculation?
(A) To provide localized thermal warmth and humidity to the developing receptive stigma
(B) To prevent contamination by unwanted pollen
(C) To permanently trap pollinating insects inside the floral structures to force fertilization
(D) To safeguard fragile floral tissues from direct exposure to intense harsh sunlight rays

82. What is the scientific term for cross-pollination where pollen from one plant is transferred to the stigma of a different plant of the same species?
(A) Allogamy (Xenogamy)
(B) Autogamy
(C) Geitonogamy
(D) Cleistogamy

83. In plant tissue culture, what is an "explant"?
(A) The solid or liquid nutrient culture medium upon which plant tissues are routinely propagated
(B) An entire mature plant that has been extracted from field soil and discarded as surplus waste
(C) A plant tissue removed for sterile culture
(D) The specific synthetic growth hormone added to the culture medium to induce adventitious root growth

84. The inherent capacity of a single plant cell to generate a whole new complete plant is known as:
(A) Pleuripotency
(B) Multipotency
(C) Unipotency
(D) Totipotency

85. The method of producing thousands of identical plants in a very short duration using tissue culture techniques is termed:
(A) Macropropagation
(B) Somatic hybridization
(C) Micropropagation
(D) Genetic editing

86. Genetic variations that are observed among plants regenerated from tissue culture are known as:
(A) Mendelian variations
(B) Somaclonal variations
(C) Continuous variations
(D) Environmental variations

87. During somatic hybridization, which chemical is most commonly used to induce the fusion of isolated plant protoplasts?
(A) Sodium chloride
(B) Sulfuric acid
(C) Colchicine
(D) Polyethylene glycol (PEG)

88. In plant tissue culture, an unorganized and undifferentiated mass of dividing cells is called:
(A) A callus
(B) An embryo
(C) A meristem
(D) An explant

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89. The high-yielding, semi-dwarf variety of rice, IR8, which played a pivotal role in the Asian Green Revolution, was developed at:
(A) IARI, India
(B) CAZRI, India
(C) IRRI, Philippines
(D) CIMMYT, Mexico

90. Arrange the essential steps of Recombinant DNA Technology in the correct order.
1. Insertion of recombinant DNA into the host cell
2. Isolation of the genetic material (DNA)
3. Cutting of DNA at specific locations
4. Amplification of the gene of interest using PCR

(A) 2, 3, 4, 1
(B) 2, 4, 3, 1
(C) 3, 2, 1, 4
(D) 1, 2, 3, 4

91. The cryIAc and cryIIAb genes produce toxins that specifically control which major pest of the cotton crop?
(A) Cotton aphids
(B) Whiteflies
(C) Spider mites
(D) Cotton bollworms

theoretical photosynthetic and agricultural productivity.

9. (C) A pure line
A pure line consists of homozygous plants produced through repeated self-pollination of a single homozygous self-fertilized individual plant across successive generations. Because the plants are homozygous at almost all genetic loci, offspring are genetically identical to each other and true-breeding, meaning they consistently produce descendants displaying identical morphological and physiological characteristics across cultivation seasons.

10. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
In controlled plant breeding, bagging emasculated bisexual flower buds using butter paper or glassine bags prevents contamination of receptive female stigmas by unwanted airborne or insect-carried pollen. Once female stigmas reach maturity, selected pollen is applied manually, and flowers are re-bagged. Therefore, bagging provides physical isolation necessary to ensure precise genetic crossing between targeted parental lines.

11. (D) Wheat and Rice
During the mid-1960s, the Green Revolution in India primarily targeted wheat and rice to overcome severe food deficits. High-yielding semi-dwarf wheat varieties from CIMMYT in Mexico and semi-dwarf rice varieties like IR8 developed by IRRI were introduced. These responsive, disease-resistant crop varieties drastically elevated national grain production, transforming India into a self-sufficient nation in cereal grain supplies.

12. (B) Wheat
Sonalika and Kalyan Sona are semi-dwarf, high-yielding, rust-resistant wheat varieties introduced across India's wheat-growing belt in 1963. Derived from Mexican germplasm introduced by Norman Borlaug and adapted locally, these varieties responded exceptionally well to fertilizer and irrigation inputs, driving the dramatic increase in wheat yield that marked the beginning of India's Green Revolution.

13. (C) A GM crop contains specific foreign genes inserted into its genome.
Genetically Modified (GM) crops differ fundamentally from traditionally bred crops by integrating specific, isolated foreign genes directly into their genome using recombinant DNA technology. Traditional breeding relies on whole-genome recombination via crossing related plants over generations. Genetic modification permits precise insertion of beneficial genes from diverse biological sources, including bacteria or unrelated organisms, bypassing interspecific reproductive barriers completely.

14. (D) Bacillus thuringiensis
The prefix "Bt" in Bt cotton refers to Bacillus thuringiensis, a ubiquitous gram-positive soil bacterium. This organism naturally produces crystalline protein inclusion bodies during sporulation that contain delta-endotoxins. When ingested by targeted insect pests, these proteins undergo solubilization and cleavage into lethal active toxins, conferring biological insect resistance to transgenic crops expressing the bacterial genes.

15. (A) Cotton bollworms
Bt cotton expresses endotoxin proteins derived from Bacillus thuringiensis genes that specifically target lepidopteran insect pests, primarily cotton bollworms such as Helicoverpa zea and Pectinophora gossypiella. Feeding on transgenic tissues damages insect midgut membranes, causing pore formation, cell lysis, paralysis, and death of larval bollworms, thereby mitigating destructive crop losses in agricultural fields.

16. (B) The toxin exists as an inactive protoxin within the bacterium.
Bacillus thuringiensis synthesizes insecticidal crystal proteins in an inactive precursor form known as a protoxin. The bacterium remains unharmed because activation requires alkaline pH conditions above 8.5 to solubilize crystalline crystals and specific proteolytic cleavage, both of which exist only within the midgut environment of susceptible insect larvae rather than inside bacterial cells.

17. (B) They are created without altering the natural DNA sequence of the plant.
Genetically Modified (GM) crops are generated explicitly by altering host plant DNA sequence through recombinant DNA techniques. Foreign

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36. (A) P-2, Q-4, R-3, S-1
In-situ conservation protects biological species within natural habitats. Ex-situ conservation preserves organisms outside original natural environments. Cryopreservation utilizes liquid nitrogen at -196 degrees Celsius to store living cells and tissue samples indefinitely. Seed banks operate specialized temperature-controlled and humidity-controlled storage facilities to preserve crop seed collections safely for extended periods.

37. (C) Loss of hybrid vigor in offspring forces annual seed repurchasing.
Hybrid seeds display high productivity due to heterosis, but saving seeds from harvested hybrid crops leads to genetic segregation and loss of hybrid vigor in the next generation. As a result, subsequent crop yields decline significantly, forcing farmers to purchase newly produced commercial hybrid seeds every year, increasing annual operational costs.

38. (B) Terminator technology
Terminator technology, formally known as Genetic Use Restriction Technology (GURT), uses genetic modification to render second-generation seeds sterile. Seed development occurs normally during harvest, but stored seeds cannot germinate when planted by farmers. This controversial approach prevents farmers from saving seed for planting in following seasons, forcing them to repurchase commercial seed repeatedly.

39. (D) New Delhi
The National Bureau of Plant Genetic Resources (NBPGR) is headquartered in New Delhi. Functioning under the Indian Council of Agricultural Research, it serves as the nodal national organization for managing, collecting, introducing, evaluating, documenting, and conserving plant genetic resources. It also maintains India's premier national gene bank for long-term conservation of seed germplasm.

40. (A) True-breeding lines
True-breeding lines refer to plant populations that produce offspring identical to themselves in phenotype and genotype when allowed to self-pollinate continuously across successive generations. These lines possess homozygous alleles at major genetic loci, preventing phenotypic segregation and ensuring uniform transmission of inherited parental traits to all subsequent offspring during agricultural seed production.

41. (C) Biofortification
Biofortification is the process of breeding agricultural crops to enhance their inherent nutritional value, including micronutrient, mineral, vitamin, and protein content. Achieved through conventional plant breeding, agronomic practices, or modern genetic engineering, biofortification targets micronutrient malnutrition and vitamin deficiencies in human populations relying on staple grain crops for daily sustenance.

42. (A) Thick cuticle and deep root system
Drought-tolerant xerophytic plant varieties display structural adaptations to reduce transpiration and maximize water acquisition in arid regions. A thick waxy leaf cuticle creates a hydrophobic barrier limiting non-stomatal water evaporation, while an extensive, deep taproot system penetrates deep soil layers to absorb subterranean moisture, enabling plants to survive prolonged dry spells.

43. (D) Halophytes
Halophytes are specialized plants naturally adapted to thrive in soils with high salt concentrations. They possess physiological mechanisms like ion compartmentalization, excretion of excess salt through leaf glands, and osmotic adjustment to prevent toxicity. Halophytes provide valuable genetic resources for identifying salt-tolerance genes, which breeders utilize to improve crop survival in saline agricultural soils.

44. (B) Jodhpur
The Central Arid Zone Research Institute (CAZRI) is located in Jodhpur, Rajasthan. Established under the Indian Council of Agricultural Research, CAZRI conducts multidisciplinary research on arid and semi-arid land management, soil-water conservation, sand dune stabilization, and developing drought-hardy crop varieties, helping sustain rural livelihoods across fragile desert agricultural ecosystems regionally.

NODIA

45. (C) Leaf and stripe rust
Himgiri is an improved semi-dwarf wheat variety developed through conventional breeding and selection in India. It possesses high yield

Finally, full transgenic plants are regenerated from transformed cells through in vitro tissue culture techniques.

27. (D) The possibility of transgene flow to wild relatives, creating superweeds.
An ecological concern regarding transgenic crop cultivation is gene flow via wind or insect pollen transfer to sexually compatible wild relatives. If transgenes conferring traits like herbicide or pest resistance escape into wild weed populations through hybridization, it can create invasive "superweeds." These resilient weeds become extremely difficult to control using standard agricultural management strategies.

28. (B) I, III, and IV
Bt cotton contains insecticidal cry genes derived from the soil bacterium Bacillus thuringiensis. These genes target specific lepidopteran pests, including cotton bollworms. Inside the insect's midgut, high alkaline pH conditions solubilize the inactive protoxin crystal into an active toxin. Because plants express their own toxin, insecticide requirements decrease significantly rather than increase.

29. (C) Somatic hybridization
Somatic hybridization is a plant tissue culture technique involving enzymatic removal of cell walls to isolate protoplasts from somatic cells of two distinct plant species or genera. The protoplasts are induced to fuse using chemicals like polyethylene glycol. The resulting somatic hybrid, such as a Pomato derived from potato and tomato, regenerates into a plant combining both genomes.

30. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Agrobacterium tumefaciens is termed a natural genetic engineer because of its evolutionary ability to infect plant cells and transfer a specific segment of its Ti plasmid, called T-DNA, into host genomic DNA. Expression of transferred T-DNA genes directs infected host cells to synthesize plant hormones and opines, inducing uncontrolled cell proliferation that forms crown gall tumors.

31. (A) Biosafety
Biosafety refers to the framework of policies, procedures, regulations, and institutional principles established to prevent biological research and modern biotechnology applications from posing unintended risks. It safeguards human health, animal welfare, and natural biodiversity against potential hazards associated with releasing living modified organisms or genetically engineered products into agricultural and environmental systems.

32. (B) Cartagena Protocol
The Cartagena Protocol on Biosafety is an international treaty supplementary to the Convention on Biological Diversity. Adopted in 2000, it establishes global regulatory standards for the safe handling, transport, transboundary movement, and environmental release of living modified organisms resulting from modern biotechnology, safeguarding global biological diversity and human health worldwide.

33. (B) Genetic Engineering Appraisal Committee (GEAC)
The Genetic Engineering Appraisal Committee (GEAC) is the apex regulatory authority operating under India's Ministry of Environment, Forest and Climate Change. It is mandated to assess research proposals involving large-scale industrial use of genetically engineered organisms and grant formal approvals for field environmental trials and commercial cultivation releases of GM crops.

34. (A) -196 degrees C
Cryopreservation preserves biological samples including seeds, pollen, tissue explants, and embryos at an ultra-low temperature of -196 degrees Celsius using liquid nitrogen. At this temperature, metabolic processes, cellular respiration, and chemical reactions halt completely, allowing long-term storage of plant germplasm and genetic material without genetic deterioration or structural decay over extended decades.

35. (C) To conserve plant genetic diversity for future crop breeding
Gene banks and seed banks serve as ex-situ conservation facilities designed to collect, catalog, and preserve genetic diversity of cultivated crops, landraces, and wild relatives. Preserving diverse germplasm prevents genetic erosion caused by habitat loss and uniform agricultural practices, ensuring breeders maintain access to valuable traits needed to develop future resilient crop varieties.

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insertion of a foreign gene sequence using recombinant DNA technology. The integrated transgene becomes part of the host genome, allowing stable expression of specific proteins and permitting stable vertical transmission of the novel genetic trait to subsequent offspring through germline inheritance.

56. (A) I, II, and III are correct
Transgenic animals serve key scientific roles, including studying gene regulation and normal physiology, producing biological therapeutic products like human proteins, and toxicity testing for candidate drugs and chemicals. Direct repopulation of wild endangered species is handled through habitat conservation and conventional captive breeding programs rather than primary transgenic technology applications.

57. (C) Biopiracy
Biopiracy refers to the unauthorized commercial exploitation or patenting of biological resources and traditional indigenous knowledge by commercial entities or multinational corporations without proper consent, legal authorization, or equitable financial compensation to host developing nations and indigenous communities who preserved and developed those biological resources continuously over past historic generations.

58. (A) Adenosine deaminase (ADA)
In 1990, the first clinical human gene therapy was performed on a four-year-old girl suffering from Severe Combined Immunodeficiency caused by adenosine deaminase deficiency. Functional ADA gene copies were inserted into her isolated lymphocytes using a retroviral vector. The engineered lymphocytes were reinfused into her bloodstream, temporarily restoring immune system function.

59. (D) Genetic Engineering Appraisal Committee
GEAC stands for the Genetic Engineering Appraisal Committee, a statutory regulatory authority under the Ministry of Environment, Forest and Climate Change in India. GEAC assesses potential environmental and public health impacts of genetically engineered organisms, evaluating field trials and issuing mandatory approvals before commercial deployment of transgenic products in agriculture.

60. (B) Indian Patents Act, 1970
The Indian Patents Act of 1970 underwent key statutory amendments to incorporate legal provisions addressing biopiracy, patent terms, and emergency exemptions. These revisions safeguard indigenous biological resources and traditional knowledge while regulating biological process patents, ensuring Indian sovereignty over genetic resources and promoting equitable benefit-sharing during commercial plant bio-product development.

61. (C) Superweeds
Superweeds are wild weed populations that acquire resistance to chemical herbicides through gene flow and pollen-mediated cross-pollination with adjacent transgenic herbicide-resistant crops. Unintentional introgressed herbicide-resistance transgenes make these weeds extremely resilient, rendering standard chemical herbicide treatments totally ineffective and requiring altered weed management practices in agricultural ecosystems nationwide.

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62. (D) ICAR
The Indian Council of Agricultural Research (ICAR) is an autonomous organization under the Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare. Serving as the premier national agency in India, ICAR coordinates, guides, and manages agricultural research, education, and extension programs across national institutes, state universities, and Krishi Vigyan Kendras.

63. (A) New Delhi
The Indian Agricultural Research Institute (IARI), commonly known as Pusa Institute, is located in New Delhi. Established as India's premier national institute for agricultural research, education, and extension, IARI led scientific developments during the Green Revolution, developing semi-dwarf high-yielding crop varieties and advancing plant breeding techniques across the entire country.

64. (B) Ex-situ conservation
Botanical gardens, zoological parks, gene banks, and seed banks represent ex-situ conservation, where threatened or economically important biological species are removed from natural habitats and preserved in controlled off-site facilities. Ex-situ techniques safeguard target species from extinction hazards, maintain genetic

potential along with genetic resistance to fungal diseases caused by Puccinia species, specifically leaf rust, stripe rust, and hill bunt, making it suitable for cultivation in rust-prone northern hill zones effectively.

46. (D) Brassica (Mustard)
Pusa Swarnim, also designated as Karan Rai, is an improved variety of Brassica juncea (mustard) developed by the Indian Agricultural Research Institute. It is bred specifically for high seed yield, oil content, and genetic resistance to white rust, a devastating fungal disease caused by Albugo candida that reduces mustard production.

47. (A) P-3, Q-2, R-1, S-3
Pusa Shubhra cauliflower is resistant to black rot fungal infection. Pusa Sadabahar chili provides dual resistance against chili mosaic virus and leaf curl virus. Pusa Komal cowpea is bred for bacterial blight resistance. Pusa Snowball K-1 cauliflower is an improved cultivar selected specifically for resistance against black rot disease in field crops.

48. (B) Mutation breeding
Mutation breeding involves exposing plant seeds or vegetative tissues to physical mutagens like gamma rays or chemical mutagens like ethyl methane sulfonate. This induces random mutations across host DNA. Breeders screen large mutagenized populations to identify rare, desirable mutants displaying superior traits like disease resistance or higher yield for incorporation into crop breeding programs.

49. (B) Rich in beta-carotene (Pro-Vitamin A)
Golden Rice is a biofortified genetically engineered rice variety designed to express beta-carotene, a precursor converted into Vitamin A by the human body. Genes encoding phytoene synthase and phytoene desaturase enzymes were integrated into the rice genome, synthesizing beta-carotene in endosperm tissue and giving the polished grains their characteristic golden coloration.

50. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Golden Rice was engineered specifically to address widespread Vitamin A deficiency in developing nations, where staple diets depend heavily on white rice lacking micronutrients. Severe Vitamin A deficiency causes irreversible childhood blindness, night blindness, and impaired immune system functions. Thus, consuming beta-carotene enriched Golden Rice provides a biofortified dietary solution to alleviate health impacts.

51. (C) Rosie
Rosie was the first transgenic cow, produced in 1997 through genetic engineering techniques. She was created by introducing a human gene sequence encoding human alpha-lactalbumin into her genome. As a result, her milk contained approximately 2.4 grams per liter of human alpha-lactalbumin, making it a more nutritionally balanced milk for human infants than natural bovine milk.

52. (D) Human alpha-lactalbumin
The transgenic cow Rosie produced milk enriched with human alpha-lactalbumin, a major whey protein found in human breast milk. Natural cow milk lacks significant amounts of this specific protein, making it less ideal for infant nutrition. Rosie's milk provided 2.4 grams per liter of alpha-lactalbumin, yielding a balanced protein profile suitable for human infants.

53. (C) To test vaccine safety prior to human use
Transgenic mice are widely generated and utilized as laboratory model organisms to test the safety and potency of newly developed vaccines before clinical testing on humans. For instance, genetically modified mice expressing human cellular receptors were used to verify polio vaccine safety, ensuring reliable assessment of adverse biological reactions prior to human distribution.

54. (B) Emphysema
Alpha-1 antitrypsin is a protease inhibitor protein produced using transgenic recombinant technology to treat emphysema, a obstructive lung condition characterized by enzymatic breakdown of alveolar elastic fibers. Administering recombinant Alpha-1 antitrypsin neutralizes excessive neutrophil elastase activity in human lung tissues, mitigating tissue destruction and halting progressive deterioration of pulmonary function in patients.

55. (D) An animal expressing a foreign gene inserted into its genome.
A transgenic animal is defined as an individual whose genome has been modified by the deliberate

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genes from bacteria, viruses, plants, or animals are integrated into the host genome. These modification procedures enable crops to express beneficial traits, including enhanced nutritional profiles, heightened tolerance to drought and salinity, and built-in resistance to insect pests.

18. (A) P-2, Q-4, R-3, S-1
Bt Cotton contains bacterial cry genes granting insect resistance against bollworms. Golden Rice incorporates genes encoding beta-carotene biosynthesis for Vitamin A enrichment. Flavr Savr Tomato utilizes antisense technology to silence polygalacturonase, delaying fruit softening and ripening. Roundup Ready Soybeans express a bacterial EPSP synthase enzyme, conferring tolerance to the non-selective herbicide glyphosate.

19. (C) cry genes
Cry genes, short for crystal protein genes, are encoded within the plasmids of Bacillus thuringiensis. These genes code for crystalline delta-endotoxin proteins that act as potent insecticidal toxins. Specific cry genes target distinct insect orders, such as cry1Ac and cry2Ab controlling lepidopteran cotton bollworms, while cry3Aa provides selective action against coleopteran beetle pests in agriculture.

20. (D) A transgenic organism
A transgenic organism is an animal, plant, or microorganism whose genetic material has been artificially altered through recombinant DNA methods by incorporating one or more stable foreign gene sequences into its genome. The integrated transgene is inherited by subsequent generations, enabling the recipient organism to express novel physiological features, metabolic pathways, or resistance mechanisms.

21. (C) Agrobacterium tumefaciens
Agrobacterium tumefaciens is a soil bacterium utilized extensively as a biological vector for plant genetic transformation. It naturally possesses the tumor-inducing Ti plasmid, which can transfer a segment of plasmid DNA into host plant cells. Genetic engineers disarm pathogenic tumor-forming genes from Ti plasmids, replacing them with desired transgenes to achieve effective plant transformation.

22. (B) T-DNA
T-DNA, or transferred DNA, is a distinct defined region on the tumor-inducing Ti plasmid of Agrobacterium tumefaciens. During natural or engineered infection, T-DNA is excised from the bacterial plasmid, transported into the host plant cell nucleus, and stably integrated into chromosomal DNA. Recombinant vectors incorporate target foreign genes within T-DNA boundaries for transgenic expression.

23. (D) Flavr Savr Tomato
The Flavr Savr tomato, released in 1994 in the United States, was the first genetically modified crop approved for human consumption. Engineered using antisense RNA technology, it suppresses polygalacturonase enzyme production. Decreased enzyme levels retard cell wall pectin breakdown, effectively slowing down fruit softening, extending shelf life, and preserving post-harvest flavor during commercial transportation and storage.

24. (A) Polygalacturonase
Polygalacturonase is a pectin-degrading enzyme that breaks down cell wall pectins in ripening fruit, causing tissue softening. In Flavr Savr tomatoes, antisense technology was applied to insert an antisense gene copy that binds to polygalacturonase messenger RNA. This prevents mRNA translation, drastically reducing enzyme concentration and significantly delaying natural ripening and softening processes.

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25. (C) Reduced reliance on chemical pesticides
Insect-resistant transgenic crops, such as Bt cotton and Bt corn, synthesize intrinsic bacterial proteins toxic to specific agricultural pests. Because these plants naturally protect themselves against insect damage, farmers require far fewer topical synthetic chemical insecticide applications. This reduction decreases production costs, limits toxic chemical runoff into surrounding aquatic ecosystems, and reduces occupational chemical exposure for farm workers.

26. (A) 2, 1, 4, 3
Constructing a transgenic plant begins with isolating the desired gene from a source donor organism using restriction enzymes. The gene is then cloned into a suitable expression vector plasmid. Next, transformation introduces the recombinant vector into recipient plant host cells.

germplasm collections, and facilitate scientific breeding, research, and conservation education programs.

65. (A) P-2, Q-3, R-1, S-4
The Central Arid Zone Research Institute is located in Jodhpur, Rajasthan. The Indian Agricultural Research Institute operates in New Delhi. The National Dairy Research Institute is situated in Karnal, Haryana. The Arid Forest Research Institute is also located in Jodhpur, conducting specialized forestry research for arid and semi-arid regions.

66. (A) Monarch butterfly
Ecological concerns arose when laboratory studies indicated that wind-blown pollen from Bt corn expressing insecticidal Cry proteins deposited onto milkweed leaves could cause mortality in monarch butterfly larvae. Monarch caterpillars feed exclusively on milkweed plants, prompting extensive field studies to evaluate pollen dispersal distances and assess real-world impacts on non-target lepidopteran species.

67. (C) Denaturation → Annealing → Extension
Polymerase Chain Reaction follows a repeated three-step thermal cycle. First, high temperatures heat double-stranded template DNA to cause denaturation into single strands. Second, annealing lowers temperatures to allow specific primers to hybridize to complementary sequences. Third, extension raises temperatures to enable thermostable DNA polymerase to synthesize complementary DNA strands continuously.

68. (D) Traditional breeding mixes thousands of genes; GM introduces a specific gene.
Traditional plant breeding recombines tens of thousands of genes from both parents during sexual hybridization, leading to unpredictable combinations that require extensive selection over multiple generations. In contrast, genetic modification precisely isolates and inserts a specific, characterized gene sequence into the recipient organism's genome, allowing direct introduction of desired traits without reshuffling background genes.

69. (C) Vavilov Centers of Origin
Vavilov Centers of Origin, identified by Russian botanist Nikolai Vavilov, represent geographic regions where major crop species were first domesticated from wild ancestors. These areas contain maximum genetic diversity, including wild relatives, traditional landraces, and primitive crop forms, serving as primary centers for collecting germplasm and discovering useful natural genes for plant breeding.

70. (B) Genetic erosion
Genetic erosion refers to the progressive loss of genetic diversity within a plant species or crop population over time. It typically occurs when traditional, diverse landraces and wild varieties are widely replaced by a few uniform, high-yielding modern cultivars, reducing the total available gene pool and increasing crop vulnerability to emerging pests and diseases.

71. (D) Molecular markers
Molecular markers are specific, recognizable DNA sequences situated at known genomic locations that are closely linked to target genes controlling desirable traits. Inherited alongside linked genes during genetic transmission, molecular markers allow plant breeders to track the presence of beneficial alleles in breeding lines without waiting for adult phenotypic expression, streamlining selection processes.

72. (A) It identifies desired traits at the seedling stage using DNA markers.
Marker-Assisted Selection utilizes DNA markers linked to desirable traits to screen individual plants at early seedling growth stages. Breeders can extract genomic DNA and detect target alleles directly, eliminating the need to grow plants to maturity or expose them to natural environmental stress, thereby dramatically accelerating plant breeding efficiency and accuracy.

NODIA

73. (C) Targeted gene editing
The CRISPR-Cas9 system is an advanced biotechnology tool derived from bacterial immune systems that enables precise, targeted gene editing in host plant genomes. Guided by a synthetic guide RNA, the Cas9 endonuclease introduces site-specific double-strand DNA breaks, permitting targeted gene knocking out, insertion, or nucleotide modification to improve plant traits efficiently.

74. (A) A molecular scissor cutting DNA at specific sites
In the CRISPR-Cas9 editing system, the Cas9 protein functions as an endonuclease, acting like molecular scissors that generate site-specific double-stranded DNA cuts. Guided to precise genomic loci by single guide RNA, Cas9 cleavage triggers natural cell repair mechanisms, facilitating knockout, insertion, or precise sequence editing of target plant genes effectively.

75. (D) Gene editing modifies existing DNA without foreign genes; transgenics insert foreign DNA.
Gene-edited crops created via systems like CRISPR-Cas9 modify, mutate, or silence endogenous host DNA sequences without incorporating foreign genetic material from other species. In contrast, transgenic crops contain recombinant DNA sequences or entire foreign genes transferred from unrelated species like bacteria, establishing fundamental technological and regulatory distinctions between these biotechnology applications.

76. (B) Higher yields improving food security and farmer incomes
Adopting high-yielding, dwarf, disease-resistant crop varieties in modern agriculture has elevated grain production per unit land area. Enhanced harvest volumes ensure national food security, reduce food import dependencies, and increase agricultural output. Higher crop production translates directly into improved farm profitability, rural economic growth, and elevated standards of living for farming communities.

77. (C) Developing resilient crops requiring fewer chemical inputs
Transgenic crops contribute significantly to global food security by incorporating built-in resistance to insect pests, diseases, drought, and extreme soil salinity. These resilient engineered plants produce stable grain yields under changing climatic conditions, minimize crop yield losses, and reduce farmer reliance on costly, environmentally damaging synthetic chemical fertilizers and pesticides.

78. (A) I, II, and III are correct
CRISPR technology is derived from bacterial adaptive immune systems against viral bacteriophages. Guided by a complementary single guide RNA, the Cas9 protein cuts targeted genomic DNA sequences with extreme precision. The technology is universally applicable across biological systems, operating effectively in plant, fungal, and animal cells alike to introduce precise genetic modifications.

79. (A) P-4, Q-3, R-1, S-2
Restriction endonucleases cleave DNA at specific palindrome recognition sequences. DNA ligases seal nicked DNA by forming phosphodiester bonds between adjacent fragments. Plasmids function as cloning vectors transporting foreign DNA into recipient host cells. Bioreactors are large culture vessels engineered to grow host micro-organisms under optimized environmental parameters for industrial scale production.

80. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Growing transgenic Bt crops reduces agricultural environmental pollution caused by toxic agrochemicals. Because Bt crops express inherent crystal delta-endotoxin proteins that kill specific insect pests, farmers decrease spraying synthetic chemical insecticides. Consequently, chemical runoff into surrounding water bodies decreases, preserving soil microbiomes and non-target organisms while mitigating ecosystem contamination effectively.

81. (B) To prevent contamination by unwanted pollen
Bagging involves covering emasculated flower buds with breathable butter paper or glassine bags before stigma receptivity. This physical barrier blocks accidental deposition of unwanted foreign airborne or vector-borne pollen grains onto receptive female stigmas. Once stigmas mature, breeders temporarily open the bag to apply selected parental pollen, ensuring strict controlled hybridization.

82. (A) Allogamy (Xenogamy)
Allogamy, or xenogamy, is cross-pollination involving pollen transfer from anthers of one plant to the receptive stigma of a different plant within the same species. Unlike autogamy or geitonogamy, xenogamy introduces distinct parental alleles during fertilization, promoting genetic recombination, increasing heterosis, and maintaining genetic variation across agricultural plant populations effectively.

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83. (C) A plant tissue removed for sterile culture
An explant is any excised segment of plant tissue, such as root tips, shoot tips, leaf discs, nodal segments, or anthers, selected and sterilized for inoculation onto nutrient culture medium in vitro. Under controlled sterile conditions, the explant undergoes cell division and differentiation, regenerating callus tissue, shoots, or somatic embryos.

84. (D) Totipotency
Totipotency is the biological capacity of a single living plant cell to divide, differentiate, and regenerate into a complete, functional organism when supplied with appropriate nutrient culture media and hormonal signals in vitro. This fundamental cellular characteristic forms the scientific foundation for plant tissue culture, micropropagation, genetic engineering, and somatic hybridization.

85. (C) Micropropagation
Micropropagation is an in vitro tissue culture technique used to rapidly produce thousands of genetically uniform plant clones from small explants within short timeframes. Cultured in aseptic environments with specified plant growth regulators, shoots proliferate exponentially, providing disease-free, high-quality planting materials for commercial horticulture and forestry propagation programs worldwide.

86. (B) Somaclonal variations
Somaclonal variations are genetic or epigenetic modifications occurring in plant tissues cultured in vitro during repeated cell division cycles. Caused by chromosomal rearrangements, point mutations, or DNA methylation shifts in callus tissue, these variations generate novel phenotypic traits among regenerated plants, providing plant breeders with unexpected genetic diversity for crop selection.

87. (D) Polyethylene glycol (PEG)
Polyethylene glycol (PEG) is a fusogenic chemical compound widely utilized in somatic hybridization to induce fusion between isolated plant protoplasts. PEG acts by altering plasma membrane surface charges and dehydrating membrane interfaces, forcing adjacent protoplast membranes into close contact to promote plasma membrane agglutination, cytoplasmic mixing, and nuclear fusion efficiently.

88. (A) A callus
In plant tissue culture, a callus is an unorganized, undifferentiated mass of actively dividing parenchymatous cells. Callus tissue forms when explants are cultured on nutrient media containing balanced ratios of auxins and cytokinins. Callus cultures can undergo organogenesis or somatic embryogenesis upon adjusting plant growth regulator concentrations to differentiate roots and shoots.

89. (C) IRRI, Philippines
IR8, a semi-dwarf, high-yielding rice variety, was developed at the International Rice Research Institute (IRRI) located in Los Banos, Philippines. Produced by crossing the Indonesian tall variety Peta with the Taiwanese dwarf variety Dee-geo-woo-gen, IR8 responded strongly to nitrogen fertilizers without lodging, tripling rice yields across Asia during the Green Revolution.

90. (A) 2, 3, 4, 1
Recombinant DNA technology follows a precise order. First, target cellular DNA is isolated and purified. Second, restriction enzymes cut DNA at specific recognition sequences to yield fragments containing desired genes. Third, PCR amplifies gene fragments exponentially. Finally, recombinant constructs are inserted into host cells via transformation for gene expression processes.

NODIA

91. (D) Cotton bollworms
Transgenic Bt cotton incorporates specific bacterial genes, cry1Ac and cry2Ab, derived from Bacillus thuringiensis. These genes encode crystalline endotoxin proteins that bind specifically to midgut receptors of cotton bollworm larvae, causing pore formation and gut lysis. Expressing these toxins protects cotton crops against destructive bollworm pest infestations in field agriculture.

92. (B) Meloidogyne incognita
Meloidogyne incognita is a soil-borne root-knot nematode that infects root systems of tobacco plants. Parasitic infection causes characteristic root gall formation, disrupting nutrient and water uptake, stunting vegetative growth, and severely reducing tobacco crop yields. Developing nematode-resistant transgenic tobacco cultivars utilizing RNA interference strategies successfully halts parasitic infestation in fields.

93. (C) RNA interference (RNAi)
Scientists developed root-knot nematode resistant tobacco plants using RNA interference (RNAi). Agrobacterium vectors introduced nematode-specific sense and antisense genes into host tobacco plants, forming double-stranded RNA. When nematodes feed on plant cells, ingested dsRNA initiates gene silencing, degrading essential parasite messenger RNA and preventing protein synthesis, rendering tobacco plants immune.

94. (D) Specific mRNA (messenger RNA)
RNA interference operates as a cellular defense mechanism by selectively degrading target messenger RNA (mRNA) molecules. Introduced double-stranded RNA is processed into short interfering RNAs, which guide the Dicer and RISC protein complexes to complementarily bind and cleavage specific parasite mRNA. Preventing mRNA translation halts protein synthesis, preventing parasite survival.

95. (A) Crown galls
Agrobacterium tumefaciens infects dicotyledonous plants, transferring its T-DNA into host genomes. Genes located within T-DNA code for auxin and cytokinin synthesis, inducing rapid, unorganized host cell division at infection sites. This excessive cell proliferation forms characteristic tumor-like growths known as crown galls, disrupting vascular transport and weakening infected host plants.

96. (B) Extra-chromosomal circular DNA in bacteria
Plasmids are double-stranded, extra-chromosomal circular DNA molecules naturally present in bacterial cells that replicate independently of genomic chromosomal DNA. Because they carry antibiotic resistance genes, origin of replication sites, and restriction sites, plasmids are engineered into recombinant vectors to transport foreign genes into recipient host organisms during bacterial transformation procedures.

97. (A) P-1, Q-2, R-3, S-4
Transgenic tobacco utilizes RNA interference to silence nematode genes. Bt cotton incorporates cry genes derived from Bacillus thuringiensis for insect protection. Golden Rice contains genes for beta-carotene biosynthesis to mitigate Vitamin A deficiency. Flavr Savr tomato employs antisense technology targeting polygalacturonase to delay fruit softening and extend storage shelf life.

98. (A) Ingo Potrykus and Peter Beyer
Ingo Potrykus of the Swiss Federal Institute of Technology and Peter Beyer of the University of Freiburg developed Golden Rice. They collaborated to introduce two daffodil genes encoding phytoene synthase and a bacterial gene encoding phytoene desaturase into rice endosperm, establishing the functional enzymatic pathway for endosperm beta-carotene synthesis.

99. (C) As edible vaccines for humans
Transgenic plants expressing pathogen antigenic proteins are engineered as edible vaccines to induce human mucosal immunity. Consuming raw plant tissues like bananas or potatoes delivers antigens directly to digestive lymphoid tissue, triggering immune responses against infectious pathogens like cholera, hepatitis B, or measles without requiring cold-chain storage or needle injections.

100. (D) Increased reliance on chemical pesticides
Genetically modified crops provide key agricultural advantages including increased stress tolerance, enhanced nutritional content, and reduced post-harvest losses. However, increased reliance on chemical pesticides is not a benefit of GM crops. Insect-resistant GM crops like Bt cotton drastically reduce chemical insecticide applications by manufacturing their own insecticidal protection against target pests.

101. (C) Bajra (Pearl Millet)
Bajra, or pearl millet, is a vital drought-tolerant cereal crop extensively cultivated across Rajasthan's arid and semi-arid landscape. Possessing deep root networks and high water-use efficiency, bajra withstands elevated temperatures, low rainfall, and poor sandy soils, serving as a primary staple grain and fodder source for rural arid zone communities.

102. (B) Khejri (Prosopis cineraria)
Khejri, scientifically Prosopis cineraria, is the official state tree of Rajasthan and a vital component of Thar desert agroforestry ecosystems. Highly adapted to arid environments, it possesses a extremely deep taproot system, fixes nitrogen to improve soil fertility, prevents desert erosion, and provides shade, nutritious fodder, fuel, and food during severe drought.

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103. (D) Liquid nitrogen
Liquid nitrogen is the cryogenic fluid universally used in cryopreservation to maintain ultra-low temperatures of -196 degrees Celsius. Submerging or placing biological specimens in liquid nitrogen vapor halts metabolic decay, enzymatic breakdown, and cell division completely, allowing germplasm, seeds, meristems, and pollen to remain viable during long-term storage across decades.

104. (A) Arid Forest Research Institute (AFRI)
The Arid Forest Research Institute (AFRI) is located in Jodhpur, Rajasthan, operating under the Indian Council of Forestry Research and Education. AFRI conducts forestry research on developing drought-tolerant tree species, restoring degraded drylands, conserving arid flora biodiversity, and improving biomass productivity across hot arid and semi-arid regions of Rajasthan and Gujarat.

105. (C) Low temperature and low moisture
Long-term preservation in modern seed banks requires low temperature and low moisture content. Orthodox seeds stored between 3 to 7 percent seed moisture levels at sub-zero temperatures (typically -18 to -20 degrees Celsius) display dramatically reduced metabolic respiration and biochemical deterioration, maintaining maximum embryo viability and germination power across extended decades.

106. (A) Somatic embryos
Somatic embryos, produced via somatic embryogenesis, are bipolar embryonic structures that develop directly from somatic or vegetative plant cells in vitro without gametic fusion or sexual fertilization. These embryos possess distinct shoot and root poles, regenerating into genetically uniform plantlets identical to the donor plant when cultured on appropriate medium.

107. (B) II, III, and V
Ex-situ conservation involves protecting biological organisms outside their natural habitats. Botanical gardens, seed banks, and cryopreservation facilities represent ex-situ conservation methods, preserving germplasm and living specimens in controlled artificial environments. In contrast, national parks and biosphere reserves represent in-situ conservation, protecting wild species and ecosystems within their natural ranges effectively.

108. (D) To improve the nutritional quality of the crops
Biofortification aims specifically to improve the intrinsic nutritional quality of human staple crops through plant breeding, agronomy, or biotechnology. By enhancing concentrations of essential micronutrients like iron, zinc, provitamin A, and quality amino acids in edible plant parts, biofortified crops help combat widespread hidden hunger and nutritional deficiencies worldwide effectively.

109. (C) Mexico
High-yielding, semi-dwarf wheat varieties introduced to India in 1963 were developed at CIMMYT in Mexico by Nobel laureate Norman Borlaug. Incorporating dwarf genes from Japanese Norin-10 wheat, these Mexican lines possessed sturdy stems resistant to lodging under heavy fertilizer application, driving dramatic yield increases during India's successful Green Revolution.

110. (D) Lysine and Tryptophan
In 2000, Indian agricultural researchers developed biofortified Quality Protein Maize (QPM) hybrids like Shakti, Rattan, and Protina. Incorporating the opaque-2 mutant gene, these maize cultivars contained double the concentration of essential amino acids lysine and tryptophan compared to existing maize hybrids, improving protein nutritional quality for direct human consumption.

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111. (A) Midgut epithelial cells
The insecticidal delta-endotoxin encoded by the Bacillus thuringiensis cry gene binds specifically to receptor proteins on the surface of larval midgut epithelial cells. Binding causes protein oligomerization and creates transmembrane pores, leading to electrolyte imbalance, cell lysis, destruction of the midgut lining, paralysis, and death of susceptible targeted insects.

112. (B) Biopatent
A biopatent is an exclusive legal right granted by a government authority to an inventor or institution for a novel biological entity, genetically modified organism, biological process, or biotechnological product. It grants exclusive commercial production and marketing rights

List I: Fibre Crops
P. Cotton
Q. Jute
R. Coir
S. Flax (Linen)
List II: Anatomical Source
1. Phloem (bast) fibres of the stem
2. Mesocarp of the fruit (husk)
3. Epidermal hair of the seed
4. Phloem (bast) fibres of the stem (Linum sp.)
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-3, S-4

56. Jute, often called the 'golden fibre', is commercially extracted from the stem of plants belonging to which genus?
(A) Hibiscus
(B) Corchorus
(C) Crotalaria
(D) Agave

57. Coir fibre, highly utilized for making eco-friendly mats, ropes, and brushes, is extracted from which plant?
(A) Banana (Musa)
(B) Coconut (Cocos nucifera)
(C) Hemp (Cannabis sativa)
(D) Sunn hemp (Crotalaria juncea)

58. Linen fabric is manufactured from the fine stem fibres of which historically important crop?
(A) Ramie (Boehmeria nivea)
(B) Kenaf (Hibiscus cannabinus) plant
(C) Flax (Linum usitatissimum)
(D) Sisal (Agave sisalana)

59. The commercial Lac insect (Kerria lacca) is most commonly reared on the twigs of which host tree?
(A) Eucalyptus globulus (Eucalyptus)
(B) Pinus roxburghii (Pine)
(C) Tectona grandis (Teak)
(D) Butea monosperma (Palash)

60. Consider the following statements regarding economically important natural fibres:
I. Cotton fibre is chemically composed almost entirely of pure cellulose.
II. Silk fibre is chemically composed of complex proteins.
III. Jute fibre is extracted from the root system of the plant.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

61. Groundnut (Peanut) is a major edible oilseed crop. What is its correct botanical name?
(A) Sesamum indicum
(B) Arachis hypogaea
(C) Helianthus annuus
(D) Ricinus communis

62. Which crop, frequently termed the 'wonder bean', is cultivated widely in southeastern Rajasthan and contains exceptionally high protein (approx. 40%) along with edible oil?
(A) Mustard
(B) Groundnut
(C) Castor
(D) Soybean

63. The economically valuable spice 'clove', renowned for its strong aroma and dental medicinal properties, is obtained from which part of the Syzygium aromaticum plant?
(A) Dried flower buds
(B) Dried underground roots
(C) Fermented seed grains
(D) Crushed aromatic leaves

64. Saffron, the world's most expensive spice by weight, is harvested by carefully collecting which reproductive part of the Crocus sativus flower?
(A) Anthers
(B) Sepals
(C) Stigmas
(D) Petals

65. Given below are two statements, one labelled as Assertion (A) and the other as Reason (R).
Assertion (A): Mustard oil possesses a very distinct, sharp, and pungent flavor.
Reason (R): The seeds contain chemical compounds known as glucosinolates, which break down into pungent allyl isothiocyanate.
Select the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

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CHAPTER 17

Economic Importance of Animals and Plants

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1. What is the primary definition of animal husbandry in the context of agricultural science?
(A) The study of wild animals in their natural habitats
(B) The scientific management and rearing of domestic animals for human benefit
(C) The process of cultivating crops using synthetic fertilizers
(D) The conservation of endangered species in zoological parks

2. Which of the following is considered the best milk-yielding buffalo breed in India and is widely reared in Rajasthan?
(A) Surti
(B) Mehsana
(C) Bhadawari
(D) Murrah

3. Which exotic breed of cattle is known globally for producing the highest quantity of milk?
(A) Holstein Friesian
(B) Jersey
(C) Brown Swiss
(D) Red Dane

4. Which of the following is a famous dual-purpose cattle breed found predominantly in the arid regions of Rajasthan?
(A) Sahiwal
(B) Red Sindhi
(C) Tharparkar
(D) Malvi

5. The term 'Operation Flood' in India is directly associated with which of the following?
(A) The White Revolution and dairy development
(B) River management and dam construction
(C) The Green Revolution and wheat production
(D) The Blue Revolution and aquaculture

6. Which specific carbohydrate is primarily found in the milk of dairy animals?
(A) Sucrose
(B) Fructose
(C) Maltose
(D) Lactose

7. Which breed of sheep is famously known as the 'Merino of Rajasthan' due to its high-quality fine carpet wool?
(A) Nali
(B) Chokla
(C) Magra
(D) Pugal

8. Where is the Central Sheep and Wool Research Institute (CSWRI) located in Rajasthan?
(A) Bikaner
(B) Jodhpur
(C) Avikanagar (Tonk)
(D) Jaisalmer

9. Which breed of poultry is most highly preferred worldwide for maximum egg production?
(A) Rhode Island Red
(B) Aseel
(C) Plymouth Rock
(D) White Leghorn

10. Match the cattle breeds in List I with their primary characteristic or origin in List II.
List I: Cattle Breeds
P. Murrah
Q. Tharparkar
R. Holstein Friesian
S. Gir
List II: Characteristics
1. High-yielding exotic breed
2. Famous milch breed native to Gujarat
3. Dual-purpose cattle breed of arid Rajasthan
4. Top milk-yielding buffalo breed of North India
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-1, Q-2, R-4, S-3

78. In the commercial paper manufacturing industry, which plant constituent acts as the fundamental structural raw material?
(A) Lignin polymer
(B) Cellulose
(C) Pectin polymer
(D) Suberin polymer

79. The plant Jatropha curcas has gained massive economic attention in arid states like Rajasthan primarily because its seeds are used to produce:
(A) Commercial Biodiesel
(B) High-protein animal feed
(C) Edible cooking oil
(D) Synthetic rubber

80. Consider the following statements regarding biofuel and bioenergy crops:
I. Jatropha curcas is widely cultivated as a commercial biodiesel yielding plant.
II. Ethanol for blending with petrol is commercially produced via the fermentation of sugarcane molasses.
III. Biogas produced from agricultural waste consists almost entirely of pure oxygen.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II, and III

81. Aside from Jatropha, which other hardy indigenous tree, scientifically known as Pongamia pinnata, is heavily promoted in India for biodiesel production?
(A) Mahua tree
(B) Karanja
(C) Sal tree
(D) Khejri tree

82. Which of the following crops serves as the primary raw material for the production of fuel-grade ethanol in India?
(A) Cotton crop
(B) Mustard crop
(C) Sugarcane
(D) Tea plantation

83. What is the predominant combustible gas found in biogas (Gobar gas), produced by the anaerobic digestion of animal dung and plant waste?
(A) Hydrogen sulphide
(B) Carbon dioxide
(C) Butane
(D) Methane

84. Which of the following is the most accurate definition of an agro-based industry?
(A) An industry manufacturing heavy agricultural machinery, equipment, and tractors
(B) An industry processing plant and animal agricultural raw materials
(C) An industry mining and processing chemical synthetic fertilizers from mineral deposits
(D) An industry focused entirely on capturing, processing, and selling wild marine fish

85. Match the commercial crops in List I with the major agro-based industry they directly support in List II.
List I: Commercial Crops
P. Sugarcane
Q. Cotton
R. Bamboo
S. Jatropha
List II: Agro-based Industry
1. Textile Industry
2. Paper Industry
3. Sugar Industry
4. Biodiesel Industry
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-4, S-3

86. Molasses, a dark, viscous by-product obtained during the processing of sugarcane, is highly valuable for which secondary industry?
(A) Commercial production of refined white sugar
(B) Industrial extraction of aromatic essential oils
(C) Manufacturing of ethyl alcohol (ethanol)
(D) Large-scale production of synthetic plastics

87. Guar gum, extracted from the seeds of the Guar plant, acts as a critical raw material in which major global industry outside of food processing?
(A) Industrial textile dyeing and processing
(B) Shale gas hydraulic fracturing
(C) Silicon semiconductor manufacturing
(D) Automotive rubber tire manufacturing

88. From which anatomical part of the Guar seed is the economically valuable 'Guar gum' chemically extracted?
(A) Seed coat (Testa)

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(C) To increase the overall water content of hide for better flexibility
(D) To prevent collagen decay and render the skin permanently durable

23. Which of the following is traditionally considered the most important draught animal for ploughing and agricultural transport in rural India?
(A) Horse
(B) Donkey
(C) Bullock
(D) Elephant

24. Which of the following represents a classic example of biological pest control using an animal predator?
(A) Spraying chemical DDT insecticides to eliminate mosquito larvae
(B) Applying potent chemical rodenticides to eliminate field mice
(C) Manual physical removal of unwanted weed plants by hand
(D) Releasing ladybird beetles to control aphid pest populations

25. Match the commercially important animals in List I with their respective economic products in List II.
List I: Animals
P. Bombyx mori
Q. Kerria lacca
R. Pinctada fucata
S. Apis mellifera
List II: Economic Products
1. Pearl
2. Beeswax
3. Silk
4. Shellac/Resin
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

26. Which National Park in Rajasthan is internationally famous for its tiger population and acts as a major hub for wildlife tourism?
(A) Keoladeo National Park
(B) Ranthambore National Park
(C) Desert National Park
(D) Mukundra Hills National Park

27. Before the advent of recombinant DNA technology, the lifesaving drug Insulin was primarily extracted on a commercial scale from the pancreas of which slaughtered animals?
(A) Cattle and Pigs
(B) Sheep and Goats
(C) Horses and Mules
(D) Poultry birds

28. Which animal holds the status of the 'State Animal' (Livestock category) of Rajasthan, reflecting its immense economic importance in the desert economy?
(A) Chinkara
(B) Blackbuck
(C) Camel
(D) Marwari Horse

29. Commercial pearl culture mainly involves the artificial insertion of a nucleus into the mantle tissue of which marine bivalve?
(A) Pila globosa
(B) Sepia officinalis
(C) Pinctada vulgaris
(D) Loligo pealeii

30. Which of the following represents the scientifically correct sequence of stages in the complete metamorphosis life cycle of the silkworm?
(A) Egg → Pupa → Larva (Caterpillar) → Adult moth
(B) Egg → Larva (Caterpillar) → Pupa → Adult moth
(C) Larva (Caterpillar) → Egg → Pupa → Adult moth
(D) Adult moth → Larva (Caterpillar) → Egg → Pupa

31. What is the standard botanical name for bread wheat, the most widely cultivated cereal crop in the world?
(A) Oryza sativa
(B) Zea mays
(C) Triticum aestivum
(D) Hordeum vulgare

32. Pulses are an essential part of the Indian diet primarily because they are exceptionally rich in which nutrient?
(A) Saturated fats
(B) Complex carbohydrates
(C) Vitamin C
(D) Dietary proteins

33. Which economically vital cash crop of Rajasthan, known botanically as Cyamopsis tetragonoloba,

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is extensively used to extract a gum utilized in the food and shale gas industries?
(A) Castor bean crop
(B) Guar (Cluster bean)
(C) Cumin seed crop
(D) Fenugreek (Methi) crop

34. Which symbiotic nitrogen-fixing bacteria is naturally found in the root nodules of leguminous pulse crops?
(A) Azotobacter
(B) Nitrosomonas
(C) Rhizobium
(D) Clostridium

35. Given below are two statements, one labelled as Assertion (A) and the other as Reason (R).
Assertion (A): Farmers frequently cultivate leguminous pulse crops in rotation with cereals like wheat.
Reason (R): Legumes possess root nodules that fix atmospheric nitrogen, thereby naturally replenishing soil fertility.
Select the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

36. Which drought-resistant tree is venerated as the 'State Tree' of Rajasthan and provides highly nutritious fodder and food pods?
(A) Tecomella undulata (Rohida)
(B) Acacia nilotica (Babul)
(C) Prosopis cineraria (Khejri)
(D) Azadirachta indica (Neem)

37. In terms of national agricultural output, Rajasthan consistently ranks first in the production of which hardy cereal crop?
(A) Pearl millet (Bajra)
(B) Paddy / Rice crop
(C) Sorghum (Jowar) crop
(D) Barley cereal crop

38. Rajasthan is the largest producer of Mustard in India. What is the botanical name of Indian mustard?
(A) Brassica oleracea
(B) Brassica rapa
(C) Brassica nigra
(D) Brassica juncea

39. To support the oilseed economy, the ICAR - Directorate of Rapeseed-Mustard Research is established at which location in Rajasthan?
(A) Bikaner
(B) Sewar (Bharatpur)
(C) Jodhpur
(D) Durgapura (Jaipur)

40. Consider the following crops grown in Rajasthan:
I. Wheat
II. Pearl Millet (Bajra)
III. Maize
IV. Gram (Chana)
Which of the above combination(s) correctly represent(s) the major Kharif (monsoon) crops?
(A) II and III only
(B) I and IV only
(C) I, II, and III only
(D) III and IV only

41. The districts of Jalore and Barmer in Rajasthan are leading producers of which highly valued medicinal plant known for its laxative seed husk?
(A) Ashwagandha (Withania somnifera)
(B) Safed Musli (Chlorophytum borivilianum)
(C) Sarpagandha (Rauvolfia serpentina)
(D) Isabgol (Plantago ovata)

42. Which important medicinal plant is botanically identified as Withania somnifera and is widely cultivated for its stress-relieving root extracts?
(A) Aloe vera plant
(B) Ashwagandha
(C) Tulsi plant
(D) Giloy plant

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43. The anti-malarial drug quinine is commercially extracted from which specific part of the Cinchona tree?
(A) Leaves
(B) Roots
(C) Bark
(D) Seeds

44. The fleshy leaves of Aloe vera are primarily harvested and processed for use in which major industry?
(A) Paper manufacturing
(B) Cosmetics and dermatology
(C) Biodiesel production
(D) Heavy timber and furniture

45. Match the medicinal plants in List I with the primary plant part utilized for extraction in List II.

List I: Medicinal Plants

P. Papaver somniferum (Opium poppy)
Q. Cinchona officinalis
R. Plantago ovata (Isabgol)
S. Rauvolfia serpentina

List II: Plant Part Utilized

1. Dried roots
2. Seed husk
3. Stem bark
4. Latex of unripe fruit capsule

(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

46. Tulsi (Holy Basil), renowned for its medicinal properties in Ayurveda, belongs to which plant family?
(A) Lamiaceae
(B) Solanaceae
(C) Fabaceae
(D) Apiaceae

47. What is the primary active biochemical compound isolated from the seeds and leaves of the Neem tree (Azadirachta indica) that acts as a potent botanical insecticide?
(A) Morphine alkaloid
(B) Azadirachtin
(C) Nicotine alkaloid
(D) Atropine alkaloid

48. The powerful analgesic and narcotic alkaloid morphine is naturally derived from which medicinal plant?
(A) Cannabis sativa
(B) Erythroxylum coca
(C) Datura stramonium
(D) Papaver somniferum

49. Giloy (Tinospora cordifolia) gained immense popularity recently. What is its principal medicinal use?
(A) As an immunomodulator and antipyretic agent
(B) As a strong natural laxative for digestive clearance
(C) As a potent surgical anesthetic in clinical medicine
(D) As a commercial heart-rate stimulant for emergencies

50. Arrange the following fundamental agricultural practices in their correct sequential chronological order:

1. Sowing of seeds
2. Preparation of soil (Ploughing)
3. Harvesting of crop
4. Irrigation

Select the correct option:
(A) 2, 1, 4, 3
(B) 1, 2, 4, 3
(C) 2, 4, 1, 3
(D) 1, 4, 2, 3

51. Which tree is highly valued for producing durable timber in India and is scientifically known as Tectona grandis?
(A) Sal
(B) Teak
(C) Shisham
(D) Deodar

52. The leaves of the Tendu tree (Diospyros melanoxylon) hold massive economic importance in rural central and western India primarily for:
(A) Feeding silkworms for commercial silk production
(B) Extracting aromatic essential oils for perfumes
(C) Producing organic green manure for soil health
(D) Serving as wrapper leaves for making Bidis

53. Botanically, commercial cotton fibres are classified as which of the following?
(A) Epidermal hairs of the seed coat
(B) Phloem bast fibres derived from the main stem
(C) Fibrous structural extensions of the root system
(D) Sclerenchyma vascular cells from the leaf veins

54. Which species of cotton, commonly referred to as upland cotton or American cotton, accounts for the vast majority of global and Indian cotton cultivation?
(A) Gossypium arboreum
(B) Gossypium herbaceum
(C) Gossypium hirsutum
(D) Gossypium barbadense

55. Match the commercially important fibre crops in List I with their specific anatomical source in the plant in List II.

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11. Ranikhet is a highly contagious and severe viral disease that primarily affects which of the following?
(A) Cattle
(B) Poultry
(C) Sheep
(D) Camels

12. The rapid increase in the production of fish and marine products in India is commonly referred to as the:
(A) Silver Revolution
(B) Blue Revolution
(C) Yellow Revolution
(D) Golden Revolution

13. Which of the following is an economically important indigenous major carp species extensively used in Indian aquaculture?
(A) Labeo rohita (Rohu)
(B) Cyprinus carpio (Common carp)
(C) Hypophthalmichthys molitrix (Silver carp)
(D) Oreochromis niloticus (Tilapia)

14. Sericulture is strictly defined as the commercial rearing of which organism?
(A) Earthworms for organic compost
(B) Lac insects for natural resin
(C) Silkworms for commercial silk
(D) Honey bees for natural beeswax

15. Given below are two statements, one labelled as Assertion (A) and the other as Reason (R).
Assertion (A): The silkworm Bombyx mori is the most widely preferred species for commercial sericulture.
Reason (R): It feeds exclusively on mulberry leaves and produces high-quality continuous white silk threads.
Select the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

16. Natural silk fibre produced by silkworms is predominantly made up of which type of biochemical molecule?
(A) Complex structural carbohydrates
(B) Lipids and natural essential oils
(C) Proteins (Fibroin and Sericin)
(D) Cellulose and hemicellulose polymers

17. Which species of honey bee is most commonly utilized for commercial apiculture due to its docile nature and high honey yield?
(A) Apis dorsata
(B) Apis mellifera
(C) Apis florea
(D) Apis cerana indica

18. Which scientist was awarded the Nobel Prize for decoding the 'waggle dance' communication method used by honey bees?
(A) Louis Pasteur
(B) Alexander Fleming
(C) Gregor Mendel
(D) Karl von Frisch

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19. Chemically, natural honey is primarily an aqueous solution composed of which two major monosaccharides?
(A) Fructose and Glucose
(B) Glucose and Galactose
(C) Sucrose and Maltose
(D) Lactose and Fructose

20. Consider the following statements regarding the social structure in a honey bee colony:
I. The queen bee is the only fertile female in the entire colony.
II. Worker bees are sterile females responsible for foraging and nursing.
III. Drone bees develop from fertilized eggs and gather nectar.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

21. Which breed of camel is recognized as one of the best riding camels in Rajasthan and is heavily utilized by border security forces?
(A) Jaisalmeri breed
(B) Bikaneri camel breed
(C) Mewari camel breed
(D) Kutchi camel breed

22. In the leather industry, what is the primary purpose of the 'tanning' process applied to animal hides?
(A) To thoroughly bleach the raw skin to a uniform pure white color
(B) To permanently dye the raw leather into vibrant synthetic colors

66. The culinary spice turmeric (Haldi), widely known for its active compound curcumin, is derived from which modified plant structure?
(A) Aerial stem bulb structure
(B) Fleshy taproot system
(C) Dried ripe fruit pod
(D) Underground rhizome

67. The Hadoti region of Rajasthan (Kota, Bundi, Baran, Jhalawar) is highly famous for the mass cultivation of which essential spice crop?
(A) Cardamom spice
(B) Coriander (Dhania)
(C) Black Pepper (Kali Mirch)
(D) Cinnamon spice

68. What is the botanical name of Cumin (Jeera), an arid spice crop predominantly cultivated in western Rajasthan and Gujarat?
(A) Foeniculum vulgare
(B) Trigonella foenum-graecum
(C) Cuminum cyminum
(D) Coriandrum sativum

69. The branch of agricultural science that specifically deals with the cultivation, processing, and economic study of fruit crops is known as:
(A) Olericulture
(B) Floriculture
(C) Silviculture
(D) Pomology

70. Match the common spices in List I with their correct botanical names in List II.
List I: Common Spices
P. Turmeric
Q. Black Pepper
R. Coriander
S. Fenugreek
List II: Botanical Names
1. Coriandrum sativum
2. Curcuma longa
3. Trigonella foenum-graecum
4. Piper nigrum
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-3, R-2, S-1

71. The 'Ber' (Indian Jujube) is a crucial fruit crop for the rural economy of arid regions. What is its botanical name?
(A) Punica granatum
(B) Ziziphus mauritiana
(C) Mangifera indica
(D) Carica papaya

72. Which district in Rajasthan is famously recognized as the state's largest producer of the citrus fruit 'Kinnow'?
(A) Jodhpur
(B) Udaipur
(C) Banswara
(D) Sri Ganganagar

73. To enhance research on desert fruits and vegetables, the ICAR - Central Institute for Arid Horticulture is located in which city?
(A) Jodhpur
(B) Bikaner
(C) Barmer
(D) Jaisalmer

74. Which of the following is traditionally consumed as a highly nutritious arid vegetable ('Sangri') in Rajasthan?
(A) Roots of the Rohida tree
(B) Unripe fruits of the Neem tree
(C) Dried pods of the Khejri tree
(D) Leaves of the Babul tree

75. Which of the following represents the correct sequence of the standard biological taxonomic hierarchy, from the broadest to the most specific category?
(A) Kingdom, Class, Phylum, Family, Order, Genus, Species
(B) Kingdom, Phylum, Class, Order, Family, Genus, Species
(C) Phylum, Kingdom, Order, Class, Genus, Family, Species
(D) Kingdom, Phylum, Order, Class, Family, Genus, Species

76. The light but strong wood of the Salix (Willow) tree holds high economic importance globally because it is the primary raw material for making:
(A) Railway sleepers
(B) Cricket bats
(C) High-quality paper pulp
(D) Musical instruments like violins

77. Botanically and economically, bamboo is officially classified under which category of plants?
(A) Hardwood timber trees
(B) Softwood conifer trees
(C) Woody shrub species
(D) Perennial giant grasses

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for a designated term, preventing unauthorized commercial exploitation by third parties worldwide.

113. (B) Basmati Rice
In 1997, an American corporation obtained a US patent on Basmati rice lines and cross-hybrids derived from traditional Indian landraces. This action generated major biopiracy concerns because Basmati rice had been cultivated and refined by Indian farmers for centuries. Legal challenges by the Indian government successfully invalidated major patent claims, protecting traditional rice germplasm.

114. (A) Mixing genes across unrelated species violates natural barriers.
Ethical debates regarding transgenic organism creation center on the philosophical and moral implications of transferring genetic material across species boundaries. Critics argue that inserting genes between unrelated kingdoms disrupts natural evolutionary integrity, manipulates life forms artificially, and creates ethical uncertainties regarding potential ecological disruptions and long-term global health consequences.

115. (C) Ministry of Environment, Forest and Climate Change
The Genetic Engineering Appraisal Committee (GEAC) functions under the Ministry of Environment, Forest and Climate Change in India. As the statutory authority mandated under Rules 1989 of the Environment Protection Act 1986, GEAC regulates research, testing, release, and commercial cultivation of genetically engineered organisms to safeguard overall environmental safety.

116. (D) Restriction Fragment Length Polymorphism
RFLP stands for Restriction Fragment Length Polymorphism, a molecular marker technique that detects variation in homologous DNA sequences. By digesting genomic DNA with restriction enzymes and analyzing fragment size variations using gel electrophoresis and hybridization probes, RFLP creates genetic maps, identifies individual genotypes, and assists marker-assisted crop selection.

117. (C) Autoclave
An autoclave is standard equipment in plant tissue culture laboratories used for moist-heat sterilization of culture media, glassware, and instruments. Operating at elevated saturated steam pressure (typically 15 psi at 121 degrees Celsius for 15-20 minutes), the autoclave destroys all vegetative bacteria, bacterial endospores, fungi, and viruses, maintaining aseptic culture conditions.

118. (A) P-1, Q-2, R-3, S-4
Spinach and Bathua were biofortified by IARI for enriched iron content. Carrots and pumpkin were enriched with Vitamin A (beta-carotene). Bitter gourd and mustard were developed with elevated Vitamin C content. Broad bean and French bean lines were selected to deliver significantly higher dietary protein concentrations for optimal human nutrition.

119. (D) Engineering non-leguminous crops to fix atmospheric nitrogen directly
Engineering non-leguminous crops like wheat, rice, and maize to fix atmospheric nitrogen directly is a major goal of plant biotechnology. Transferring nif gene clusters or engineering root associations would allow non-legumes to convert atmospheric nitrogen into usable ammonia, drastically reducing global reliance on synthetic nitrogenous urea fertilizers in agriculture.

120. (A) Prolonged drought
Prolonged drought is a major abiotic stress, defined as a non-living environmental factor that negatively impacts plant growth, cellular physiology, and agricultural yield. Unlike biotic stresses caused by living organisms like fungi, insects, or nematodes, abiotic stresses include physical and chemical conditions like extreme temperatures, salinity, flooding, and water deficit.

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(B) Embryo (Cotyledons)
(C) Radicle
(D) Endosperm

89. 'Vermicompost', a highly nutrient-rich organic fertilizer utilized in sustainable agriculture, is produced primarily through the digestive actions of:
(A) Termites
(B) Earthworms
(C) Nematodes
(D) Dung beetles

90. Given below are two statements, one labelled as Assertion (A) and the other as Reason (R).
Assertion (A): The cultivation of Jatropha curcas is heavily promoted by the government in the arid regions of Rajasthan.
Reason (R): Jatropha is a highly drought-resistant plant whose seed extract is an excellent source of biodiesel.
Select the correct answer from the options given below:
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

91. In India, the highly profitable practice of cultivating white button mushrooms (Agaricus bisporus) involves growing the fungus on which specific substrate?
(A) Prepared organic compost
(B) Living tree trunks
(C) Pure sterile sand
(D) Chemical nutrient solutions

92. In agricultural economics, what does the term 'Mixed Farming' explicitly refer to?
(A) Simultaneously sowing two or more distinct cereal crops in the exact same agricultural field
(B) Alternating the cultivation of commercial cash crops and regular food crops across successive years
(C) Blending organic manures with synthetic chemical fertilizers during initial soil tillage preparation
(D) Cultivating crops alongside raising livestock on the same farm

93. A core principle of sustainable organic farming is to strictly avoid the use of which of the following inputs?
(A) Traditional crop rotation and field resting techniques
(B) Synthetic fertilizers and pesticides
(C) Naturally prepared farmyard manure and compost
(D) Environmentally safe biological pest control agents

94. Integrated Pest Management (IPM) is a sustainable agricultural approach that emphasizes:
(A) Achieving total eradication of every insect species from agricultural fields using massive high-dose chemical sprays
(B) Managing pests below economic damage levels using integrated biological, cultural, and chemical tools
(C) Relying entirely and exclusively on insect-resistant genetically modified crop varieties without using external inputs
(D) Completely abandoning all active agricultural pest management practices and allowing natural ecosystems to take their course

95. Arrange the following organisms to form a correct sequential terrestrial food chain demonstrating natural biological control:
1. Snake
2. Grass (Producer)
3. Frog
4. Grasshopper
5. Hawk

Select the correct option:
(A) 2, 4, 3, 1, 5
(B) 2, 3, 4, 1, 5
(C) 4, 2, 3, 5, 1
(D) 2, 4, 1, 3, 5

96. Which biological phenomenon allows leguminous plants to thrive without the application of artificial nitrogen fertilizers?
(A) Active specialized photosynthesis occurring within subterranean root system tissues
(B) Symbiotic nitrogen fixation in root nodules
(C) Direct atmospheric absorption of gaseous nitrogen through open leaf stomatal pores
(D) Parasitic uptake and extraction of organic nitrogen compounds from adjacent plants

97. The beneficial symbiotic association between the root system of higher plants and specific

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30. (B) Egg → Larva (Caterpillar) → Pupa → Adult moth
The silkworm exhibits complete metamorphosis comprising four distinct biological developmental stages. The lifecycle initiates when female moths lay eggs, which hatch into voracious silk-producing larvae. After feeding on foliage, larvae spin protective cocoons and enter the pupal stage before ultimately emerging as fully mature adult moths to complete reproduction.

31. (C) Triticum aestivum
Triticum aestivum, commonly known as hexaploid bread wheat, is the most widely cultivated cereal crop globally. Characterized by high gluten content and favorable baking properties, this staple grain supplies essential carbohydrate calories and dietary proteins to human populations, forming the foundational core of global food security and agricultural trade.

32. (D) Dietary proteins
Pulses are indispensable components of human nutrition, serving as the primary source of dietary proteins for vegetarian populations across India. Derived from leguminous crops like gram, lentil, and pigeon pea, pulses contain abundant essential amino acids, lysine, dietary fiber, and vital minerals, supplementing grain-based carbohydrate diets to ensure balanced nutrition.

33. (B) Guar (Cluster bean)
Guar, botanically known as Cyamopsis tetragonoloba, is a resilient leguminous cash crop widely grown in the arid zones of Rajasthan. Its seeds contain endosperm rich in galactomannan gum, an industrial hydrocolloid extensively utilized as a thickening, stabilizing, and gelling agent across food processing, pharmaceuticals, and shale gas hydrofracturing operations.

34. (C) Rhizobium
Rhizobium is a genus of symbiotic soil bacteria that infects the root hairs of leguminous plants, forming specialized root nodules. Within these nodules, the bacteria convert atmospheric gaseous nitrogen into bioavailable ammonium compounds using the nitrogenase enzyme complex, enriching soil fertility and providing essential nitrogenous nutrients directly to the host plant.

35. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Crop rotation incorporating leguminous pulse crops alongside non-leguminous cereals is a fundamental agricultural practice. Because legumes host symbiotic Rhizobium bacteria within root nodules that fix free atmospheric nitrogen into soil nutrients, this rotation naturally replenishes depleted soil fertility, improves soil structure, and optimizes crop productivity without excessive reliance on synthetic fertilizers.

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36. (C) Prosopis cineraria (Khejri)
Prosopis cineraria, locally known as Khejri, is designated as the State Tree of Rajasthan due to its profound ecological and economic roles in hyper-arid desert ecosystems. This deep-rooted legume fixes atmospheric nitrogen, stabilizes shifting sand dunes, and yields protein-rich livestock fodder alongside edible pods known locally as Sangri.

37. (A) Pearl millet (Bajra)
Rajasthan leads India in the total production of pearl millet, locally known as Bajra. This hardy Kharif cereal crop thrives in sandy soils and dry, warm climates characterized by low rainfall. Providing essential dietary carbohydrates, protein, and minerals, Bajra represents a crucial food security crop and fodder source across arid regions.

38. (D) Brassica juncea
Indian mustard, botanically designated as Brassica juncea, is a prominent Rabi oilseed crop extensively cultivated across northern and western India, particularly Rajasthan. Recognized for its high seed oil content and characteristic pungent flavor, this crop yields valuable edible cooking oil alongside protein-rich seed cake utilized as nutritious livestock feed.

39. (B) Sewar (Bharatpur)
The ICAR - Directorate of Rapeseed-Mustard Research is headquartered at Sewar in Bharatpur district, Rajasthan. Established to conduct basic, strategic, and applied research on brassica oilseeds, this national institute develops high-yielding varieties, crop protection protocols, and sustainable production technologies to boost national edible oil production.

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(B) Northwestern region (Bikaner, Sri Ganganagar)
(C) Hadoti region (Kota, Bundi)
(D) Matsya region (Alwar, Bharatpur)

108. The internationally renowned luxury textile fiber 'Pashmina' is economically harvested from the soft undercoat of which high-altitude animal?
(A) Sheep
(B) Yak
(C) Rabbit
(D) Goat

109. 'Isinglass', a highly pure form of collagen utilized economically in the food industry to clarify wines and beers, is obtained from which part of a fish?
(A) Swim bladder
(B) Epidermal scales
(C) Hepatic liver tissue
(D) Respiratory gills

110. Match the common cereal crops in List I with their respective botanical names in List II.
List I: Cereal Crops
P. Maize
Q. Rice
R. Barley
S. Sorghum (Jowar)
List II: Botanical Names
1. Oryza sativa
2. Hordeum vulgare
3. Sorghum bicolor
4. Zea mays
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

111. The commercial plantation crop 'Tea', vital for international exports, is scientifically identified by which botanical name?
(A) Coffea arabica
(B) Camellia sinensis
(C) Theobroma cacao
(D) Piper betle

112. The globally traded beverage 'Coffee' is prepared by roasting and grinding which specific part of the Coffea plant?
(A) Dried leaves
(B) Root bark
(C) Flower petals
(D) Seeds (Beans)

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113. Natural commercial rubber is harvested by tapping the milky latex from the trunk of which tropical tree?
(A) Ficus benghalensis
(B) Acacia senegal
(C) Hevea brasiliensis
(D) Tectona grandis

114. Which of the following is strictly classified as a Rabi (winter-sown) crop in the standard Indian agricultural cycle?
(A) Paddy (Rice)
(B) Maize
(C) Pearl Millet (Bajra)
(D) Wheat

115. Among Indian buffalo breeds, which breed is scientifically documented to produce milk with the highest percentage of fat (often exceeding 8-10%)?
(A) Murrah
(B) Bhadawari
(C) Jaffarabadi
(D) Nili-Ravi

116. In veterinary physiology, the rapid ejection or 'let-down' of milk from the udder of a dairy animal is controlled by the release of which hormone?
(A) Prolactin
(B) Estrogen
(C) Oxytocin
(D) Adrenaline

117. Anthrax is an economically devastating, highly fatal, and zoonotic disease that primarily affects cattle and sheep. It is caused by:
(A) A pathogenic virus
(B) A pathogenic fungus
(C) Protozoan parasite
(D) A bacterium

118. Foot and Mouth Disease (FMD), which causes severe economic loss in the dairy and livestock sector due to reduced milk yield and lameness, is caused by:
(A) A bacterium
(B) A virus (Aphthovirus)
(C) A fungal infection
(D) Nutritional deficiency

119. Mastitis is one of the most common and costly diseases in the global dairy industry. It strictly refers to the damaging inflammation of which anatomical structure?

soil fungi, which vastly improves phosphorus absorption, is called:
(A) Lichen association
(B) Mycorrhiza
(C) Rhizobium bacteroid
(D) Haustorial hyphae

98. The floating water fern 'Azolla' is widely utilized as an excellent biofertilizer in the cultivation of which staple crop due to its association with Anabaena?
(A) Wheat crop
(B) Maize crop
(C) Rice (Paddy)
(D) Sugarcane crop

99. Who among the following is universally recognized and honored as the 'Father of the Green Revolution in India' for introducing high-yielding wheat varieties?
(A) Verghese Kurien
(B) Norman Borlaug
(C) Homi J. Bhabha
(D) M. S. Swaminathan

100. Match the specific agricultural revolutions in List I with their targeted commodity in List II.
List I: Agricultural Revolutions
P. Green Revolution
Q. White Revolution
R. Blue Revolution
S. Yellow Revolution
List II: Commodity
1. Milk and Dairy Products
2. Edible Oilseeds
3. Food Grains (Wheat and Rice)
4. Fish and Aquaculture
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-1, R-3, S-2

101. The prestigious 'Borlaug Award', named after Nobel laureate Dr. Norman Borlaug, is awarded for outstanding research and contributions in which field?
(A) Space Science and Satellite Technology
(B) Creative Literature and World Peace
(C) Advanced Medical Surgery and Research
(D) Agriculture

102. In a honey bee colony, 'Royal Jelly' is a highly nutritious secretion used exclusively for feeding which member to ensure their specific development?
(A) Developing drone larvae
(B) The queen bee
(C) Adult worker bees
(D) Foraging scouts

103. The venom of a honey bee sting is medically utilized in specialized 'Apitherapy'. What is the primary active peptide present in bee venom?
(A) Melittin
(B) Histamine
(C) Formic acid
(D) Serotonin

104. What is the precise botanical name of the 'Sevan' grass, a highly nutritious and drought-resistant fodder grass crucial to the livestock economy of western Rajasthan (Jaisalmer)?
(A) Cenchrus ciliaris
(B) Cynodon dactylon
(C) Lasiurus scindicus
(D) Panicum maximum

105. Consider the following statements regarding standard dairy processing:
I. Colostrum, the first milk secreted after calving, is highly rich in antibodies crucial for calf immunity.
II. Pasteurization involves heating milk to kill pathogenic bacteria without destroying its nutritional value.
III. Homogenization is the process of completely removing all fat to create skimmed milk.
Which of the above statement(s) is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

106. The distinct pleasant aroma and flavor of traditionally churned butter and ghee are primarily attributed to the presence of which chemical compound formed during fermentation?
(A) Acetic acid
(B) Formaldehyde
(C) Diacetyl
(D) Lactic acid

107. The famous indigenous cattle breed 'Rathi', known for excellent milk production in harsh arid climates, originates from which region of Rajasthan?
(A) Mewar region (Udaipur, Chittorgarh)

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ANSWERS

1. (B) The scientific management and rearing of domestic animals for human benefit
Animal husbandry encompasses the systematic care, breeding, management, and housing of domesticated livestock to optimize yields of milk, meat, fiber, and draft power. Applying scientific principles ensures optimal animal health, enhanced productivity, efficient nutrition, and selective breeding, providing substantial economic security, nutritional resources, and sustainable livelihoods for farming communities worldwide.

2. (D) Murrah
The Murrah buffalo is globally recognized as the premier milk-yielding breed, originating from the Punjab and Haryana regions and widely reared across northwestern India, including Rajasthan. Characterized by tightly curled horns and jet-black coats, these animals exhibit superior lactation capacity, resilience to environmental conditions, and form the backbone of commercial dairy enterprises.

3. (A) Holstein Friesian
Originating in the Netherlands, Holstein Friesian cattle represent the highest milk-producing exotic breed in the world. Recognizable by their distinctive black-and-white patched coats, these cows demonstrate exceptional lactation potential under controlled management systems, making them indispensable for commercial dairy farming and crossbreeding programs aimed at significantly enhancing overall milk yields.

4. (C) Tharparkar
Tharparkar is an indigenous dual-purpose cattle breed originating in the Thar Desert region of Rajasthan and Pakistan. Highly valued for its exceptional ability to withstand extreme thermal stress and forage scarcity, it produces good quantities of milk while males provide efficient draft power for agricultural operations in arid agro-ecological zones.

5. (A) The White Revolution and dairy development
Launched in 1970 under the guidance of Dr. Verghese Kurien, Operation Flood transformed India from a milk-deficient country into the world's largest milk producer. By establishing a nationwide modern dairy cooperative network, it empowered rural farmers, optimized processing infrastructure, stabilized consumer prices, and drove the historic movement known as the White Revolution.

6. (D) Lactose
Lactose is the primary carbohydrate component found in mammalian milk, synthesized exclusively within the mammary glands from glucose and galactose molecules. Serving as a crucial source of metabolic energy for newborn offspring, lactose also contributes to osmotic water transport into milk and provides a distinct mild sweetness across various dairy products.

7. (B) Chokla
The Chokla sheep breed, native to the Shekhawati region of Rajasthan, is designated as the 'Merino of Rajasthan' due to its production of fine, dense carpet wool. Exhibiting outstanding hardiness in arid environments, this breed yields high-quality fleeces utilized extensively in textile industries for manufacturing premium carpets and fabrics.

8. (C) Avikanagar (Tonk)
Established under the Indian Council of Agricultural Research, the Central Sheep and Wool Research Institute is situated at Avikanagar in Tonk district, Rajasthan. The premier research facility conducts multidisciplinary studies on sheep and goat breeding, nutrition, health, fiber technology, and meat production to enhance small ruminant productivity across arid regions.

9. (D) White Leghorn
The White Leghorn is an exotic Mediterranean poultry breed globally renowned for its extraordinary egg-laying capacity and efficient feed conversion. Characterized by lightweight bodies and white plumage, these birds lay exceptionally high numbers of large white-shelled eggs annually, making them the primary foundation stock for commercial layer poultry production systems worldwide.

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10. (A) P-4, Q-3, R-1, S-2
Matching cattle breeds with their primary characteristics shows that Murrah is the top milk-yielding buffalo, Tharparkar serves as a dual-purpose arid breed, Holstein Friesian represents a high-yielding exotic cattle breed, and Gir is a famous milch cattle breed native to Gujarat, establishing a clear link between livestock genetic profiles and economic roles.

11. (B) Poultry
Ranikhet disease, globally known as Newcastle disease, is a highly contagious viral infection affecting domestic and wild poultry species. Caused by an avian paramyxovirus, it induces severe respiratory distress, neurological disturbances, diarrhea, and high mortality rates, posing a significant economic threat to poultry farming enterprises requiring mandatory vaccination protocols.

12. (B) Blue Revolution
The Blue Revolution denotes the strategic initiative and rapid expansion of aquaculture and fisheries management aimed at increasing aquatic animal production. By modernizing inland fish farming, marine fisheries, hatchery management, and processing infrastructure, this movement significantly enhanced national food security, nutritional intake, export revenues, and rural employment generation across water bodies.

13. (A) Labeo rohita (Rohu)
Labeo rohita, commonly known as Rohu, is a major indigenous carp species heavily cultivated across freshwater aquaculture systems in India. Occupying column feeder niches in composite fish culture, this fast-growing species displays high nutritional value, excellent market demand, and rapid growth rates, rendering it economically essential for sustainable commercial fish farming.

14. (C) Silkworms for commercial silk
Sericulture is the specialized agro-based enterprise centered on the systematic rearing of silkworms for commercial raw silk production. Involving host plant cultivation, silkworm feeding, cocoon harvesting, and thread reeling, sericulture provides lucrative rural employment, integrates agricultural labor with cottage manufacturing, and yields natural textile fibers highly prized in global markets.

15. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Bombyx mori is the dominant domesticated silkworm species utilized in commercial sericulture because its larvae feed strictly on mulberry foliage. This exclusive feeding preference enables the production of fine, continuous, high-tensile white silk filaments within cocoons, directly explaining why this species is universally preferred for producing superior quality commercial silk fabric.

16. (C) Proteins (Fibroin and Sericin)
Natural silk filaments secreted by silkworms consist strictly of structural proteins, primarily fibroin and sericin. Fibroin forms the insoluble structural core providing high mechanical strength, elasticity, and natural luster, while sericin acts as a soluble gummy coating that binds twin fibroin filaments together until processed during commercial silk degumming.

17. (B) Apis mellifera
Apis mellifera, commonly known as the European honey bee, is the most widely domesticated species in modern commercial apiculture. Favored for its docile temperament, high honey storage capacity, low swarming tendency, and adaptability to artificial movable-frame hives, this species plays an indispensable economic role in commercial honey and beeswax production.

18. (D) Karl von Frisch
Austrian ethologist Karl von Frisch received the Nobel Prize in Physiology or Medicine in 1973 for deciphering the complex symbolic language of honey bees. He demonstrated that worker bees perform intricate 'waggle dances' inside the hive to communicate precise directional vector coordinates and distances to rich environmental nectar and pollen sources.

19. (A) Fructose and Glucose
Natural honey is a concentrated aqueous solution primarily composed of two simple monosaccharides, fructose and glucose, which together constitute over seventy percent of its dry matter. Derived from floral nectar processed by honey bee salivary enzymes like invertase, these digestible sugars impart high energetic value, hygroscopic moisture retention, and characteristic sweetness.

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20. (A) I and II only
In a honey bee colony, caste differentiation establishes that the single queen is the fertile female responsible for egg laying, while sterile female worker bees perform foraging, nursing, and hive maintenance. Drones are haploid males originating from unfertilized eggs through parthenogenesis whose sole function is mating, making statements I and II correct.

21. (A) Jaisalmeri breed
The Jaisalmeri camel is an acclaimed riding breed native to the arid desert tracts of western Rajasthan. Known for its elegant physique, agility, speed, and endurance over sand dunes, this breed is extensively deployed by border security forces and rural communities for patrol operations, transportation, and desert travel across harsh environments.

22. (D) To prevent collagen decay and render the skin permanently durable
Tanning is a vital chemical process in leather processing that stabilizes raw animal hide collagen proteins. By cross-linking collagen fibers with natural tannins or synthetic chromium salts, tanning prevents putrefaction, enhances thermal and microbial resistance, and transforms perishable biological skin into flexible, durable, and commercially useful leather products.

23. (C) Bullock
Bullocks have historically served as the primary draught animals across Indian agricultural landscapes, providing essential motive power for farm operations. Their physical strength, docility, and endurance make them ideal for pulling heavy ploughs, operating water-lifting devices, hauling agricultural transport carts, and sustaining rural farming operations where motorized machinery remains limited.

24. (D) Releasing ladybird beetles to control aphid pest populations
Biological control utilizes natural living organisms to manage target pest populations, avoiding synthetic chemical contamination. Releasing predatory ladybird beetles into agricultural fields effectively reduces damaging aphid populations through natural predation, preserving ecological balance, reducing chemical resistance risks, and maintaining sustainable crop protection within integrated pest management systems.

25. (A) P-3, Q-4, R-1, S-2
Matching economic organisms to products shows that Bombyx mori produces natural silk filaments, Kerria lacca secretes natural lac resin, Pinctada fucata forms marine pearls within mantle tissues, and Apis mellifera synthesizes natural beeswax, establishing a direct link between specialized animal biology and valuable commercial harvestable commodities.

26. (B) Ranthambore National Park
Located in the Sawai Madhopur district of Rajasthan, Ranthambore National Park is internationally celebrated for its wild Bengal tiger population and historical fort environment. As a major tiger reserve under Project Tiger, it serves as a critical biodiversity conservation zone while driving substantial eco-tourism revenues for regional rural economies.

27. (A) Cattle and Pigs
Prior to modern recombinant DNA technology, therapeutic insulin for diabetes management was harvested from the pancreatic tissues of slaughtered cattle and pigs. Although biologically active in humans, bovine and porcine insulin occasionally induced allergic immune responses, driving the transition toward bio-engineered human insulin synthesized by genetically modified micro-organisms.

28. (C) Camel
Declared the official State Animal under the livestock category in 2014, the camel holds unmatched cultural and economic significance in Rajasthan. Adapted to extreme arid conditions, it provides essential milk, draught power, transportation, and fiber, serving as the traditional 'Ship of the Desert' vital for sustaining arid rural livelihoods.

29. (C) Pinctada vulgaris
Commercial pearl culture relies on marine bivalve mollusks, predominantly Pinctada vulgaris and related pearl oyster species. The process involves implanting a small foreign nucleus alongside mantle donor tissue into the oyster's gonad or mantle layer, triggering continuous secretion of nacreous aragonite layers that gradually encapsulate the nucleus into a pearl.

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50. (A) 2, 1, 4, 3
Standard crop production follows a strict sequential chronological order. Farmers begin with soil preparation through ploughing to aerate the land, followed by sowing high-quality seeds. Subsequent application of water via irrigation supports crop development, culminating in the harvesting of mature crop yields, establishing the logical agricultural sequence 2, 1, 4, 3.

51. (B) Teak
Tectona grandis, widely known as Teak, is a prized tropical hardwood tree species native to south and southeast Asia. Highly valued for its dense, durable wood resistant to decay, moisture, and termite attack, Teak timber is the preferred material for high-end furniture, ship construction, structural framing, and fine architectural woodwork.

52. (D) Serving as wrapper leaves for making Bidis
The leaves harvested from the Tendu tree (Diospyros melanoxylon) hold immense economic importance for forest-dwelling communities across central and western India. Possessing flexible texture and resistance to decay, Tendu leaves are collected seasonally to serve as natural wrappers for hand-rolled Indian bidis, generating substantial non-timber forest revenue and rural seasonal employment.

53. (A) Epidermal hairs of the seed coat
Botanically, natural cotton fibers are elongated unicellular outgrowths emerging from the epidermal layer of the seed coat inside cotton bolls. Composed of virtually pure cellulose, these seed trichomes develop during fruit maturation and are harvested and ginned to produce thread and spun yarns essential for global textile manufacturing.

54. (C) Gossypium hirsutum
Gossypium hirsutum, commonly referred to as upland or American cotton, accounts for over ninety percent of global and Indian commercial cotton production. Valued for its high lint yield, spinning quality, medium-long fiber staple, and adaptability, this tetraploid species forms the foundational raw material powering modern industrial textile manufacturing.

55. (A) P-3, Q-1, R-2, S-4
Matching fiber crops with plant structures demonstrates that cotton originates from seed epidermal hairs, jute is extracted from stem phloem bast fibers, coir comes from the fibrous fruit mesocarp of coconuts, and flax fiber is derived from Linum stem bast tissue, highlighting structural diversity in natural industrial fiber extraction.

56. (B) Corchorus
Jute, widely termed the 'golden fibre', is an eco-friendly natural fiber derived from plants of the genus Corchorus, primarily Corchorus capsularis and Corchorus olitorius. Extracted via stem retting from phloem bast tissues, soft shiny jute fibers are spun into coarse threads used for manufacturing durable burlap sacks, twine, and carpets.

57. (B) Coconut (Cocos nucifera)
Coir is a tough, resilient natural structural fiber harvested from the thick fibrous husk, or mesocarp, surrounding the coconut fruit (Cocos nucifera). High in lignin content, coir fibers are exceptionally resistant to saltwater decay and mechanical abrasion, making them ideal for manufacturing floor mats, ropes, brushes, and erosion-control geotextiles.

58. (C) Flax (Linum usitatissimum)
Linen fabric is produced from fine bast fibers located inside the stem phloem tissue of flax plants, botanically known as Linum usitatissimum. Retting and mechanical scutching isolate these strong, highly absorbent cellulose fibers, which are spun into smooth yarn to manufacture breathable, durable clothing, household textiles, and specialized paper.

59. (D) Butea monosperma (Palash)
Kerria lacca, the commercial lac insect, is reared on specialized host trees, among which Butea monosperma (Palash) serves as a primary host in India. Female insects feed on tender succulent twigs and secrete a protective resinous crust, which is harvested and processed into commercial shellac for polishes, varnishes, and cosmetics.

60. (A) I and II only
Plant and animal fibers display distinct biochemical compositions. Cotton consists almost exclusively of pure cellulose carbohydrate polymers, whereas natural silk represents a animal protein fiber synthesized from fibroin and sericin. Jute fiber is extracted from stem

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40. (A) II and III only
Kharif crops are sown during the onset of the monsoon season and harvested in autumn. Among the listed options, Pearl Millet (Bajra) and Maize are primary Kharif crops requiring warm growing conditions, whereas Wheat and Gram are classical Rabi crops sown during winter, making combination II and III strictly correct.

41. (D) Isabgol (Plantago ovata)
Isabgol, botanically known as Plantago ovata, is a highly valuable medicinal crop cultivated extensively in western Rajasthan districts like Jalore and Barmer. The dry seed husk contains abundant mucilage, serving as a natural dietary fiber laxative widely prescribed to treat gastrointestinal ailments, regulate cholesterol, and improve digestive health globally.

42. (B) Ashwagandha
Ashwagandha, botanically classified as Withania somnifera, is a renowned medicinal herb in traditional Ayurvedic medicine. Cultivated for its tuberous roots containing bioactive withanolides, Ashwagandha acts as a potent adaptogen, relieving physical stress, enhancing vitality, bolstering immune system functions, and improving overall cognitive and muscular endurance.

43. (C) Bark
Quinine is a naturally occurring alkaloid extracted from the dried trunk and branch bark of Cinchona trees, belonging to the family Rubiaceae. Historically serving as the primary anti-malarial drug worldwide, quinine interferes with Plasmodium parasite growth within human red blood cells, demonstrating the immense pharmacological value of medicinal plant bark extracts.

44. (B) Cosmetics and dermatology
The succulent fleshy leaves of Aloe vera contain abundant clear gel rich in polysaccharides, vitamins, and antioxidants. Extensively processed in the cosmetics and dermatology industries, Aloe vera gel acts as a soothing skin moisturizer, anti-inflammatory agent, and wound-healing treatment, forming a core ingredient in numerous skincare and topical pharmaceutical products.

45. (A) P-4, Q-3, R-2, S-1
Matching medicinal plants with harvested parts reveals that Papaver somniferum yields latex from capsule pods, Cinchona provides stem bark for quinine, Plantago ovata yields seed husk for laxatives, and Rauvolfia serpentina yields roots containing reserpine, reflecting precise botanical sourcing for specialized pharmaceuticals and active herbal compounds.

46. (A) Lamiaceae
Tulsi, or Holy Basil (Ocimum sanctum), belongs to the botanical family Lamiaceae, commonly known as the mint family. Celebrated in Ayurvedic systems for its antimicrobial, adaptogenic, and immunomodulatory properties, Tulsi leaves contain essential aromatic oils rich in eugenol, camphor, and caryophyllene, which confer distinct therapeutic and metabolic benefits.

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47. (B) Azadirachtin
Azadirachtin is a complex tetranortriterpenoid limonoid compound isolated from the seeds, leaves, and bark of the Neem tree (Azadirachta indica). Serving as a potent natural biopesticide, it acts as an insect antifeedant, repellent, and growth disruptor, offering an eco-friendly, biodegradable alternative to synthetic chemical insecticides in sustainable agriculture.

48. (D) Papaver somniferum
Morphine is a powerful benzylisoquinoline alkaloid naturally derived from the dried latex exudate of unripe capsules of the opium poppy, Papaver somniferum. Functioning as a potent central nervous system analgesic, morphine remains a fundamental prescription drug in clinical medicine for managing severe acute and chronic pain under strict regulatory control.

49. (A) As an immunomodulator and antipyretic agent
Tinospora cordifolia, commonly known as Giloy or Guduchi, is an indispensable climbing shrub in traditional medicine. Rich in bioactive alkaloids, glycosides, and lactones, Giloy is primarily utilized as a powerful immunomodulator and antipyretic agent, effectively enhancing bodily immunity against infections, reducing chronic fevers, and detoxifying internal organ systems.

(A) The respiratory tract (Lungs)
(B) The digestive tract (Rumen)
(C) The hoof and foot joints
(D) The mammary glands (Udder)

120. Macaroni wheat, which is rich in gluten and highly preferred for manufacturing pasta, semolina (suji), and noodles, belongs to which specific species?
(A) Triticum aestivum
(B) Triticum dicoccum
(C) Triticum durum
(D) Triticum spelta

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bast tissue rather than roots, making statements I and II strictly accurate.

61. (B) Arachis hypogaea
Groundnut, or peanut, is scientifically named Arachis hypogaea. This valuable annual leguminous oilseed crop exhibits geocarpy, wherein fertilized flowers bend downward and push developing seed pods underground to mature. Groundnut seeds contain high concentrations of edible oil and plant protein, making them vital for human nutrition and vegetable oil processing.

62. (D) Soybean
Soybean, often designated as the 'wonder bean', is a versatile leguminous crop cultivated extensively in southeastern Rajasthan and central India. Containing approximately forty percent high-quality protein and twenty percent edible oil, soybean plays a dual economic role as a major vegetable oil source and an essential protein constituent for food and feeds.

63. (A) Dried flower buds
Commercial cloves are the dried, unopened floral buds harvested from the evergreen tree Syzygium aromaticum, belonging to the family Myrtaceae. Renowned for their warm, pungent flavor and rich concentration of essential oil dominated by eugenol, cloves are widely utilized as a culinary spice, food preservative, and oral dental analgesic.

64. (C) Stigmas
Saffron, the most valuable spice by weight globally, consists of the dried tri-lobed stigmas collected by hand from flowers of Crocus sativus. Rich in active compounds like crocin, picrocrocin, and safranal, saffron imparts a distinct golden-yellow hue, floral aroma, and characteristic flavor to gourmet foods and pharmaceutical preparations.

65. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Mustard oil is distinguished by its sharp, pungent aroma and characteristic bite. This sensory profile occurs because mustard seeds contain sulphur-rich glucosinolate compounds which, upon mechanical seed crushing and enzymatic hydrolysis by myrosinase, release volatile allyl isothiocyanate, directly explaining the underlying biochemical origin of the oil's distinct flavor profile.

66. (D) Underground rhizome
Turmeric, botanically designated as Curcuma longa, is derived from the modified underground stem known as a rhizome. The harvested rhizomes are boiled, dried, and ground into a vivid yellow powder containing curcumin, a polyphenol compound valued for its natural coloring properties, culinary applications, and proven anti-inflammatory health benefits.

67. (B) Coriander (Dhania)
The Hadoti region of southeastern Rajasthan, encompassing districts like Kota, Baran, Bundi, and Jhalawar, is nationally famous for producing high-grade coriander (Dhania). Grown as an aromatic seed spice, coriander thrives in the fertile black soils of Hadoti, supplying extensive domestic spice markets and international export channels.

68. (C) Cuminum cyminum
Cuminum cyminum is the botanical name of Cumin, locally known as Jeera. Belonging to the family Apiaceae, this delicate annual herb produces small dried fruits heavily enriched with essential oils. Cumin is a dominant seed spice grown in the dry regions of western Rajasthan and Gujarat, essential for world cuisine.

69. (D) Pomology
Pomology is the specialized branch of horticultural science dedicated to the study, cultivation, enhancement, and post-harvest management of fruit-bearing plants. Covering tree fruits, berries, and nuts, pomological research optimizes orchard management, breeding, disease resistance, and fruit quality to maximize economic returns and food production within agricultural production systems.

70. (A) P-2, Q-4, R-1, S-3
Correctly matching common culinary spices with their scientific classifications pairs Turmeric with Curcuma longa, Black Pepper with Piper nigrum, Coriander with Coriandrum sativum, and Fenugreek with Trigonella foenum-graecum, establishing exact taxonomic identification for these widely cultivated and economically important aromatic spice crops utilized extensively across global food processing industries.

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(B) The surgical procedure involving the complete physical removal of blood clots from an affected artery.
(C) The technological production and synthetic manufacturing of artificial blood cells in a laboratory setting.
(D) The intravenous transfer of blood or blood components into a recipient's circulation.

32. What is the primary life-threatening risk associated with an incompatible ABO blood transfusion?
(A) A sudden and massive increase in the total white blood cell count leading to high persistent fever.
(B) Rapid multiplication and aggregation of blood platelets causing immediate unintended healing of vascular walls.
(C) Agglutination and destruction of transfused red cells blocking critical blood vessels.
(D) The complete physiological transformation of circulating red blood cells directly into functional white blood cells.

33. Before a blood transfusion takes place, which of the following compatibilities must be strictly checked?
(A) Only the ABO blood group of the donor and recipient.
(B) Both the ABO blood group and the Rh factor.
(C) Only the Rh factor of the donor and recipient.
(D) The body weight and blood pressure of the recipient only.

34. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A person with blood group O negative is called a universal donor.
Reason (R): Blood group O negative red blood cells lack A, B, and Rh antigens, minimizing the risk of a transfusion reaction.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

35. Identify the incorrect statement regarding blood compatibility.
(A) A person with group B can safely receive blood from a group AB donor.
(B) A person with group A can safely receive blood transfusions from a group O donor.
(C) A person with group AB can receive blood from A, B, AB, and O groups.
(D) A person with group O can only receive blood from a group O donor.

36. A patient with blood group B requires an emergency blood transfusion. Which of the following blood groups can be safely transfused to this patient?
(A) Group B and Group AB only
(B) Group A and Group O only
(C) Group B and Group O only
(D) Group AB and Group O only

37. What does the term "autologous blood transfusion" refer to?
(A) The collection and reinfusion of a patient's own blood.
(B) The medical procedure of transfusing blood directly from a non-human animal to a human.
(C) The specialized process of transfusing artificial synthetic blood substitutes into a patient.
(D) The practice of transfusing donated blood exclusively between genetically identical twins.

38. What is the maximum duration that donated whole blood can typically be stored under proper refrigeration in a blood bank?
(A) 2 to 3 days
(B) 10 to 15 days
(C) 35 to 42 days
(D) 3 to 6 months

39. Which of the following chemicals is commonly used in blood banks to prevent collected blood from clotting?
(A) Sodium chloride
(B) Sodium citrate
(C) Potassium cyanide
(D) Calcium carbonate

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40. Match the recipient's blood group in List I with the compatible donor blood groups in List II.
List I: (Recipient Blood Group)
P. Recipient A
Q. Recipient B
R. Recipient AB
S. Recipient O
List II: (Compatible Donor Groups)

into bio-diesel fuel, while the resulting seed cake provides valuable organic biofertilizer, making it ideal for wasteland afforestation and renewable energy.

82. (C) Sugarcane
Sugarcane serves as the principal agricultural feedstock for industrial ethanol production in India. Fermentation of sugarcane juice, syrup, and molasses yields bio-ethanol, which is processed and blended with petrol under national biofuel initiatives to reduce automobile carbon emissions, conserve foreign exchange, and support the domestic agricultural economy.

83. (D) Methane
Biogas, produced through the anaerobic digestion of organic materials like animal dung and crop residues by methanogenic bacteria, consists predominantly of methane gas (55–70%) alongside carbon dioxide. Methane acts as the primary combustible component, providing clean, renewable energy for domestic cooking, electricity generation, and lighting in rural areas.

84. (B) An industry processing plant and animal agricultural raw materials
An agro-based industry is specifically defined as any manufacturing enterprise that uses raw agricultural materials derived from plants and animals to process finished consumer goods. Examples include sugar mills, textile factories, vegetable oil refineries, and dairy processing plants, bridging primary farm output with industrial economic growth and commercial markets.

85. (A) P-3, Q-1, R-2, S-4
Matching agricultural crops with their corresponding processing industries pairs Sugarcane with the sugar industry, Cotton with textile manufacturing, Bamboo with paper pulp production, and Jatropha with biodiesel processing, illustrating the foundational role of primary crop cultivation in supporting diverse commercial agro-industrial manufacturing sectors nationwide.

86. (C) Manufacturing of ethyl alcohol (ethanol)
Molasses is a dense, dark byproduct obtained during the industrial crystallization of sugar from sugarcane juice. High in fermentable residual sugars, molasses serves as the chief raw material for industrial distilleries, where yeast fermentation converts these sugars into ethyl alcohol (ethanol) for biofuel, pharmaceuticals, and industrial applications.

87. (B) Shale gas hydraulic fracturing
Guar gum, a natural galactomannan hydrocolloid derived from guar seeds, plays a critical role in global oil and shale gas hydraulic fracturing operations. Its superior water-thickening properties increase fracturing fluid viscosity, allowing efficient transportation of proppants deep into rock fissures to unlock trapped natural gas and crude oil reserves.

88. (D) Endosperm
Economically valuable guar gum is extracted specifically from the endosperm layer of the guar seed (Cyamopsis tetragonoloba). Accounting for approximately one-third of the seed mass, the endosperm contains high concentrations of water-soluble galactomannan polysaccharides, which are separated from the outer hull and inner embryo to be ground into industrial gum powder.

89. (B) Earthworms
Vermicompost is an eco-friendly organic fertilizer produced through the joint action of specialized earthworms (such as Eisenia fetida) and microorganisms decomposing organic waste. As earthworms consume organic matter, their digestive tracts process and excrete nutrient-rich castings loaded with plant-available nitrogen, phosphorus, potassium, and beneficial soil microbes for sustainable agriculture.

90. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Jatropha curcas cultivation is actively promoted across arid and semi-arid regions of Rajasthan due to its exceptional drought tolerance and ability to thrive on degraded marginal lands. The seed oil serves as a primary source for high-quality biodiesel, directly justifying government policies promoting its cultivation for bioenergy and wasteland rehabilitation.

91. (A) Prepared organic compost
Commercial cultivation of white button mushrooms (Agaricus bisporus) requires a specially formulated organic compost substrate. Prepared through controlled aerobic fermentation of agricultural residues such as wheat straw, poultry manure, and gypsum, this nutrient-dense

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but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

11. Who is credited with the discovery of the ABO blood group system in humans?
(A) William Harvey
(B) Karl Landsteiner
(C) Alexander Fleming
(D) Gregor Mendel

12. In the context of blood groups, what are antigens?
(A) Catalytic enzymes found inside the nucleus of white blood cells
(B) Specific molecules located on the surface of red blood cells
(C) Soluble protein components circulating within the blood plasma
(D) Metabolic waste products transported by red blood cells

13. Which blood group is characterized by the complete absence of both A and B antigens on the red blood cells?
(A) Blood Group O
(B) Blood Group A
(C) Blood Group B
(D) Blood Group AB

14. A person with blood group AB has which of the following antibodies in their blood plasma?
(A) Only Anti-A
(B) Only Anti-B
(C) Neither Anti-A nor Anti-B
(D) Both Anti-A and Anti-B

15. Match the blood groups in List I with the corresponding antigens present on their red blood cells in List II.
List I: (Blood Groups)
P. Blood Group A
Q. Blood Group B
R. Blood Group AB
S. Blood Group O
List II: (Antigens Present)
1. Both Antigen A and Antigen B
2. No Antigens
3. Only Antigen A
4. Only Antigen B
(A) P-3, Q-4, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-3, R-1, S-2
(D) P-1, Q-2, R-3, S-4

16. Antibodies corresponding to the ABO blood groups are primarily located in which part of the blood?
(A) On the surface of Red Blood Cells
(B) In the blood plasma
(C) Inside the White Blood Cells
(D) Attached to the platelets

17. Which specific blood type is universally recognized as the universal donor in medical emergencies?
(A) O positive
(B) AB positive
(C) AB negative
(D) O negative

18. Which specific blood type is universally recognized as the universal recipient?
(A) AB positive
(B) O positive
(C) O negative
(D) AB negative

19. Which of the following is not a recognized blood phenotype in the human ABO blood group system?
(A) A
(B) B
(C) C
(D) O

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20. Read the following statements regarding the inheritance of blood groups:
Statement I: The human ABO blood group is an example of multiple allelism.
Statement II: A single gene with three different alleles controls the ABO blood group in humans.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

21. How many different genotypes are possible for the ABO blood group system in the human population?
(A) 3
(B) 4
(C) 6
(D) 8

is awarded annually to recognize outstanding research, innovation, and practical contributions in the field of agricultural sciences and food production. It honors dedicated scientists whose work significantly advances crop yield, nutritional security, and sustainable farming systems worldwide.

102. (B) The queen bee
Royal Jelly is a protein-rich glandular secretion produced by young worker nurse bees. While all bee larvae receive Royal Jelly for their initial days of development, only chosen larvae designated to become queen bees are fed Royal Jelly exclusively throughout their larval stage, triggering morphological differentiation into fertile adult queen bees.

103. (A) Melittin
Melittin is the principal bioactive peptide component found in honey bee venom (apitoxin), constituting roughly fifty percent of its dry weight. Demonstrating potent anti-inflammatory, antimicrobial, and analgesic properties, melittin is the primary agent studied in apitherapy for treating chronic joint diseases like rheumatoid arthritis under medical supervision.

104. (C) Lasiurus scindicus
Lasiurus scindicus, locally known as Sevan grass, is a highly nutritious, drought-resistant perennial pasture grass native to the hyper-arid Thar Desert region of western Rajasthan, especially Jaisalmer. Possessing deep root systems, Sevan grass binds drifting desert soils and provides essential forage for livestock during prolonged drought conditions.

105. (A) I and II only
Standard dairy processing mandates that colostrum, the initial post-calving milk secretion, deliver crucial maternal antibodies to newborn calves for passive immunity. Pasteurization heat-treats milk to eradicate harmful pathogens while preserving nutritional quality. Homogenization breaks down fat globules to prevent cream separation rather than removing fat, making statements I and II correct.

106. (C) Diacetyl
The characteristic pleasant aroma and distinct flavor of fermented butter, cultured cream, and traditionally churned ghee are primarily produced by the volatile chemical compound diacetyl. Formed as a byproduct during the fermentation of citrate by starter lactic acid bacteria like Lactococcus lactis, diacetyl defines classic high-quality dairy sensory profiles.

107. (B) Northwestern region (Bikaner, Sri Ganganagar)
The Rathi cattle breed is a famous indigenous milch breed originating from the hyper-arid northwestern tracts of Rajasthan, including Bikaner, Ganganagar, and Hanumangarh districts. Well-adapted to harsh desert climates and heat stress, Rathi cows produce substantial yields of rich milk, serving as a vital economic asset for local pastoralists.

108. (D) Goat
Pashmina, one of the world's finest natural luxury fibers, is harvested from the soft undercoat down of Changthangi goats reared in high-altitude Himalayan regions. Harvested during seasonal molting, these exceptionally fine cashmere fibers possess remarkable thermal insulation properties, making them highly prized for weaving luxury shawls, scarves, and winter garments.

109. (A) Swim bladder
Isinglass is a pure form of collagen derived specifically from the dried swim bladders of various fish species, particularly sturgeon and carps. Extensively utilized in commercial beverage processing as a fining agent, isinglass binds floating yeast particles and suspended organic proteins, causing them to precipitate out to clarify beers and wines.

110. (A) P-4, Q-1, R-2, S-3
Matching staple cereal crops with their formal scientific names pairs Maize with Zea mays, Rice with Oryza sativa, Barley with Hordeum vulgare, and Sorghum with Sorghum bicolor, establishing accurate botanical identifications for key grain crops cultivated globally for human food, animal feed, and industrial biofuel applications.

111. (B) Camellia sinensis
Tea, one of the world's most widely consumed aromatic beverages, is scientifically identified as Camellia sinensis. Cultivated in tropical and subtropical hill plantations, the young tender leaves and buds of this evergreen shrub undergo specialized processing, oxidation, and drying to produce various commercial commercial tea varieties like black, green, and oolong.

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compost provides the essential carbon, nitrogen, and moisture required for fungal mycelial growth and fruiting body development.

92. (D) Cultivating crops alongside raising livestock on the same farm
Mixed farming is an integrated agricultural system where crop cultivation and livestock raising are conducted concurrently on the same farm unit. This multi-enterprise approach enhances farm sustainability, optimizes resource recycling by utilizing crop residues for fodder and animal manure for soil fertility, and diversifies income sources to mitigate market and climatic risks.

93. (B) Synthetic fertilizers and pesticides
Organic farming is an environmentally sustainable agricultural framework that strictly prohibits the application of synthetic chemical fertilizers, artificial pesticides, growth regulators, and genetically modified organisms. Instead, it relies on ecological processes, crop rotations, green manures, organic composting, and biological pest management to preserve soil vitality, biodiversity, and ecosystem health.

94. (B) Managing pests below economic damage levels using integrated biological, cultural, and chemical tools
Integrated Pest Management is a holistic, ecological strategy designed to maintain crop pest populations below economic injury levels rather than seeking total chemical eradication. By combining cultural practices, biological control agents, host-plant resistance, and selective judicious chemical application, IPM minimizes environmental pollution, prevents pest resistance, and ensures economically viable crop protection.

95. (A) 2, 4, 3, 1, 5
A classic terrestrial food chain represents energy flow across trophic levels. Solar energy is captured by primary producers (Grass), which are eaten by primary consumers (Grasshopper). Secondary consumers (Frog) prey on insects, tertiary consumers (Snake) consume frogs, and apex predators (Hawk) hunt snakes, establishing the correct logical biological food sequence 2, 4, 3, 1, 5.

96. (B) Symbiotic nitrogen fixation in root nodules
Leguminous plants thrive in nitrogen-deficient soils without synthetic fertilizers due to symbiotic nitrogen fixation. Specialized soil bacteria of the genus Rhizobium infect root tissues to form nodules, where they fix inert atmospheric nitrogen into ammonium compounds, directly supplying essential nutrients to the host plant in exchange for photosynthetic carbohydrates.

97. (B) Mycorrhiza
Mycorrhiza defines the beneficial symbiotic association formed between soil fungi and the root systems of higher plants. Fungal hyphae extend far beyond the root zone, significantly increasing soil surface area absorption of water and immobile mineral nutrients, particularly phosphorus, while receiving plant carbohydrates in return to enhance crop growth and stress tolerance.

98. (C) Rice (Paddy)
Azolla is a small floating freshwater fern that forms a symbiotic relationship with the nitrogen-fixing cyanobacterium Anabaena azollae. Widely utilized as an effective biofertilizer in flooded rice (paddy) fields, Azolla fixes substantial atmospheric nitrogen, enriches organic matter in soil, suppresses weed growth, and enhances overall crop yields sustainably.

99. (D) M. S. Swaminathan
Dr. M. S. Swaminathan is internationally honored as the 'Father of the Green Revolution in India'. A visionary agricultural scientist, he collaborated with Nobel laureate Norman Borlaug to introduce high-yielding semi-dwarf wheat and rice varieties into Indian farming, dramatically transforming national food security, preventing famine, and achieving grain self-sufficiency.

100. (A) P-3, Q-1, R-4, S-2
Matching agricultural revolutions with their target commodities pairs the Green Revolution with food grains like wheat and rice, the White Revolution with milk development, the Blue Revolution with aquaculture production, and the Yellow Revolution with edible oilseed expansion, reflecting major strategic government initiatives aimed at national agricultural self-sufficiency.

101. (D) Agriculture
The prestigious Borlaug Award, named in honor of Nobel laureate Dr. Norman Borlaug,

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CHAPTER 18
Blood Groups, Transfusion and Rh Factor

1. What is the approximate percentage of plasma in human blood by volume?
(A) 35 percent
(B) 45 percent
(C) 55 percent
(D) 75 percent

2. Which of the following blood cells is primarily responsible for the transport of oxygen in the human body?
(A) Leukocytes
(B) Thrombocytes
(C) Lymphocytes
(D) Erythrocytes

3. What is the main function of white blood cells (WBCs) in the human body?
(A) Fighting infections and providing immunity
(B) Transporting carbon dioxide to the lungs
(C) Producing hormones for growth
(D) Assisting in the clotting of blood

4. Which component of the blood plays the most critical role in the coagulation process?
(A) Red blood cells
(B) White blood cells
(C) Platelets
(D) Blood plasma

5. Match the blood components in List I with their scientific names in List II.
List I: (Blood Components)
P. Red Blood Cells
Q. White Blood Cells
R. Platelets
S. Liquid portion of blood
List II: (Scientific Names)
1. Thrombocytes
2. Plasma
3. Erythrocytes
4. Leukocytes
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-2, R-3, S-4

6. What is the average life span of a mature red blood cell in a healthy human?
(A) 10 to 15 days
(B) 30 to 45 days
(C) 120 days
(D) 200 days

7. Which of the following statements about human blood plasma is incorrect?
(A) It is a pale yellow, slightly alkaline liquid.
(B) Fibrinogen is completely absent in blood plasma.
(C) It contains about 90 to 92 percent water.
(D) It transports digested food and hormones.

8. Consider the following statements regarding mature human Red Blood Cells (RBCs):
I. They possess a biconcave disc shape.
II. They lack a true nucleus.
III. They contain the iron-rich protein haemoglobin.
IV. They are produced in the spleen in healthy adults.
Which of the above statements are correct?
(A) I, II, and III
(B) II, III, and IV
(C) I, III, and IV
(D) I, II, and IV

9. Which mineral is essentially found at the center of the haemoglobin molecule?
(A) Calcium
(B) Magnesium
(C) Copper
(D) Iron

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): White blood cells are often called the soldiers of the human body.
Reason (R): White blood cells engulf foreign particles and produce antibodies to fight diseases.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true

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112. (D) Seeds (Beans)
The globally popular beverage coffee is prepared from the processed, roasted, and ground seeds, commonly known as beans, derived from berries of the Coffea plant (primarily Coffea arabica and Coffea canephora). Rich in caffeine and aromatic compounds, roasted coffee beans provide stimulating beverages deeply embedded in global culinary and economic trade.

113. (C) Hevea brasiliensis
Commercial natural rubber is harvested from the Para rubber tree, botanically known as Hevea brasiliensis. By making precise diagonal incisions into the bark, farmers tap the tree's latex vessels to collect a milky fluid suspension containing cis-1,4-polyisoprene, which is coagulated and processed to produce elastic natural rubber for global manufacturing.

114. (D) Wheat
Wheat is a classical Rabi (winter-sown) crop cultivated across India during the dry cool months. Sown between October and December and harvested in spring, wheat requires moderate temperatures during early growth and warm sunlit days for grain ripening, distinguishing it from monsoon Kharif crops such as Paddy, Maize, and Pearl Millet.

115. (B) Bhadawari
The Bhadawari buffalo breed, native to the copper-colored regions of Uttar Pradesh and Madhya Pradesh, is scientifically recognized for producing milk with exceptional butterfat content, often ranging between 8 to 13 percent. This remarkably high fat concentration makes Bhadawari milk particularly valuable for traditional butter and ghee manufacturing in Indian dairy systems.

116. (C) Oxytocin
The ejection or 'let-down' of milk from the mammary glands of dairy animals is a neuroendocrine reflex mediated by the hormone oxytocin. Secreted by the posterior pituitary gland in response to tactile udder stimulation or environmental cues, oxytocin causes contraction of myoepithelial cells surrounding alveoli, forcing milk into teat cisterns for milking.

117. (D) A bacterium
Anthrax is a severe, acute zoonotic disease affecting livestock and humans, caused by the spore-forming rod-shaped bacterium Bacillus anthracis. Characterized by sudden death, high fever, and unclotted dark blood discharge from body orifices, anthrax bacterial spores survive for decades in contaminated soil, posing a significant biosecurity and livestock health hazard.

118. (B) A virus (Aphthovirus)
Foot and Mouth Disease is an extremely contagious viral infection affecting cloven-hoofed animals such as cattle, buffaloes, sheep, and pigs. Caused by an Aphthovirus belonging to the Picornaviridae family, it causes painful vesicles and blisters on the tongue, mouth, and hooves, resulting in severe lameness, reduced milk yield, and substantial economic losses.

119. (D) The mammary glands (Udder)
Mastitis is an economically devastating disease in the dairy industry characterized by persistent inflammation of the mammary gland tissue in the udder. Typically caused by bacterial pathogens like Staphylococcus aureus invading teat canals, mastitis causes tissue damage, altered milk composition, reduced milk yield, and significant financial losses requiring rigorous hygienic herd management.

120. (C) Triticum durum
Macaroni wheat, scientifically known as Triticum durum, is a tetraploid wheat species renowned for its hard kernels and high gluten protein content. Semolina derived from durum wheat possesses superior viscoelastic properties, making it the globally preferred raw material for manufacturing pasta products, noodles, couscous, and traditional semolina (suji) foods.

NODIA

22. What is the correct genetic representation (genotype) for an individual with blood group O?
(A) IA i
(B) IB i
(C) IA IB
(D) ii

23. Consider the following statements regarding the inheritance of the AB blood group:
I. Alleles IA and IB are completely dominant over allele i.
II. When alleles IA and IB are present together, they both express their own types of sugars.
III. The expression of both IA and IB together is an example of incomplete dominance.
Which of the above statements is/are incorrect?
(A) I only
(B) II only
(C) III only
(D) I and II

24. If a child has blood group O, and the mother has blood group A and the father has blood group B, what must be the genotypes of the parents?
(A) Mother IA IA, Father IB IB
(B) Mother IA IA, Father IB i
(C) Mother IA i, Father IB i
(D) Mother IA i, Father IB IB

25. Which of the following is the correct sequence of steps for testing an unknown blood group in a laboratory?
(A) Add Anti-A and Anti-B sera to separate blood drops → Mix well → Prick finger to collect blood → Observe for agglutination
(B) Prick finger to collect blood → Add Anti-A and Anti-B sera to separate blood drops → Mix well → Observe for agglutination
(C) Observe for agglutination → Prick finger to collect blood → Mix well → Add Anti-A and Anti-B sera
(D) Add Anti-A and Anti-B sera → Prick finger to collect blood → Observe for agglutination → Mix well

26. When determining a blood group, what visible reaction occurs if the red blood cells contain the antigen corresponding to the added antiserum?
(A) Agglutination or clumping of the red blood cells occurs.
(B) The blood sample immediately changes its color to deep blue.
(C) The red blood cells completely dissolve and disappear in fluid.
(D) The blood drop rapidly evaporates from the testing slide surface.

27. Identify the correct statement regarding blood agglutination.
(A) It is the normal physiological process of new blood cell formation inside the bone marrow.
(B) It occurs when specific antigens and corresponding antibodies react to form clumps.
(C) It is the primary physiological process responsible for transporting oxygen throughout the body.
(D) It is a specialized medical treatment therapeutic procedure routinely given to cure severe anaemia.

28. The AB blood group in humans is a classic example of which genetic phenomenon?
(A) Pleiotropy
(B) Codominance
(C) Epistasis
(D) Polygenic inheritance

NODIA

29. If an individual possesses the genotype IA IA, what will be their resultant blood group?
(A) Blood Group A
(B) Blood Group B
(C) Blood Group AB
(D) Blood Group O

30. Match the genotypes in List I with the resulting blood groups in List II.
List I: (Genotypes)
P. IA i
Q. ii
R. IA IB
S. IB i
List II: (Blood Groups)
1. Blood Group O
2. Blood Group AB
3. Blood Group A
4. Blood Group B
(A) P-3, Q-1, R-2, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-2, R-1, S-4
(D) P-1, Q-3, R-4, S-2

31. What is the medical definition of a blood transfusion?
(A) The clinical process of filtering metabolic waste products from the blood using a specialized machine.

71. (B) Ziziphus mauritiana
The Indian Jujube or Ber, botanically named Ziziphus mauritiana, is a crucial fruit tree species suited for hot, arid climates. Featuring extensive root systems and drought tolerance, Ber trees produce sweet, nutrient-dense fruits, providing crucial dietary vitamins and sustainable agricultural income for farmers operating in low-rainfall environments.

72. (D) Sri Ganganagar
Sri Ganganagar district, located in northern Rajasthan, is renowned as the leading producer of Kinnow, a high-yielding citrus hybrid. Benefiting from extensive canal irrigation systems like the Indira Gandhi Canal, the region provides ideal soil and climate conditions, earning it recognition as the primary citrus basket of the state.

73. (B) Bikaner
The ICAR - Central Institute for Arid Horticulture is located at Bikaner, Rajasthan. The institute undertakes dedicated scientific research aimed at improving desert fruit and vegetable crops, enhancing water-use efficiency, developing stress-tolerant crop cultivars, and advancing sustainable horticultural practices tailored specifically for hyper-arid agro-ecological environments across the region.

74. (C) Dried pods of the Khejri tree
Sangri refers to the slender unripe seed pods collected from the Khejri tree (Prosopis cineraria). A vital traditional food source in desert regions, Sangri pods are harvested, consumed fresh, or dried for long-term storage, forming an essential, protein-rich ingredient in the famous Rajasthani culinary specialty known as Panchkutta.

75. (B) Kingdom, Phylum, Class, Order, Family, Genus, Species
The standard biological taxonomic hierarchy organizes living organisms into hierarchical ranks reflecting evolutionary relationships. Ranging from the most inclusive category to the most specific individual grouping, the correct biological sequence progresses sequentially through Kingdom, Phylum, Class, Order, Family, Genus, and Species, establishing a systematic framework for global biodiversity classification.

76. (B) Cricket bats
Wood from the Salix tree, commonly known as Willow (particularly Salix alba var. caerulea), possesses unique light weight, high impact resistance, and structural toughness. These superior mechanical properties make Willow timber the premier, globally preferred raw material for manufacturing high-quality professional cricket bats and specialized sporting goods equipment.

77. (D) Perennial giant grasses
Bamboo belongs botanically to the family Poaceae, making it officially classified as a group of perennial giant woody grasses rather than true timber trees. Characterized by hollow jointed stems called culms, bamboo exhibits extremely rapid growth rates, serving as an eco-friendly renewable material for construction, paper, furniture, and handicrafts.

78. (B) Cellulose
Cellulose, a linear structural polysaccharide composed of glucose monomers, serves as the fundamental raw material in commercial paper manufacturing. Derived from plant wood pulp, cotton, or non-wood fibers, cellulose fibers interlock during wet-laying and drying processes to form durable, cohesive paper sheets utilized globally in packaging and printing.

79. (A) Commercial Biodiesel
Jatropha curcas is a drought-hardy non-edible oilseed shrub widely cultivated across arid lands in Rajasthan. Its seeds yield oil rich in triglycerides that undergoes transesterification to produce commercial biodiesel, providing a renewable alternative liquid fuel that reduces reliance on imported fossil fuels while restoring degraded wasteland soils.

80. (A) I and II only
Bioenergy resources rely on diverse agricultural feedstock. Jatropha curcas serves as a prominent biodiesel crop, while fuel-grade ethanol is produced commercially through yeast fermentation of sugarcane molasses. Biogas consists predominantly of methane and carbon dioxide rather than oxygen, rendering statements I and II correct regarding renewable bioenergy production.

81. (B) Karanja
Pongamia pinnata, locally known as Karanja, is a nitrogen-fixing tree promoted across India as a sustainable biodiesel source. Its non-edible seeds contain high oil content suitable for conversion

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1. Can receive from B and O
2. Can receive only from O
3. Can receive from A, B, AB, and O
4. Can receive from A and O

(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-3, S-4

41. What is the minimum age required to become a voluntary blood donor under standard medical guidelines?
(A) 16 years
(B) 18 years
(C) 21 years
(D) 25 years

42. What is the generally accepted minimum body weight required for a healthy individual to safely donate blood?
(A) 35 kg
(B) 45 kg
(C) 65 kg
(D) 75 kg

43. Consider the following general eligibility conditions for a voluntary blood donor:
I. The donor's body temperature and pulse should be normal.
II. The donor should not have consumed alcohol in the last 24 hours.
III. The donor must be currently suffering from a mild viral fever.
IV. The donor's haemoglobin level must be above 12.5 g/dL.
Which of the above statements represent the correct combination of eligibility criteria?
(A) I, II, and III
(B) II, III, and IV
(C) I, II, and IV
(D) I, III, and IV

44. What is the medically recommended time interval between two consecutive whole blood donations for a healthy adult male?
(A) 1 month
(B) 3 months
(C) 6 months
(D) 12 months

45. What is the standard volume of whole blood typically collected from a donor during a single donation session?
(A) 100 to 150 ml
(B) 350 to 450 ml
(C) 750 to 850 ml
(D) 1000 to 1200 ml

46. Which of the following is a misconception or myth regarding voluntary blood donation?
(A) Donating blood can help save multiple lives in emergencies.
(B) New blood cells are naturally regenerated by the body within a few weeks of donation.
(C) Donating blood causes permanent physical weakness and long-term immunity loss.
(D) Sterile, single-use needles are used during the blood donation process.

47. Which of the following best describes a primary function of a blood bank?
(A) To manufacture synthetic human blood using chemical compounds.
(B) To surgically extract bone marrow from patients with severe anaemia.
(C) To distribute medicines for genetic blood disorders directly to patients' homes.
(D) To collect, test, process, and safely store donated human blood.

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48. What is the minimum acceptable haemoglobin level for an individual to be eligible for blood donation?
(A) 8.5 g/dL
(B) 10.0 g/dL
(C) 12.5 g/dL
(D) 15.5 g/dL

49. Arrange the following steps of the standard voluntary blood donation process in the correct chronological order:
I. Actual blood collection using sterile equipment
II. Resting and receiving post-donation refreshments
III. Medical screening and haemoglobin test
IV. Filling out the donor registration and consent form
Which of the following options represents the correct sequence?
(A) IV, III, I, II
(B) III, IV, I, II
(C) I, II, III, IV
(D) IV, I, III, II

50. Which of the following diseases is mandatorily screened for in every unit of blood collected by a recognized blood bank?

(A) Packed Red Blood Cells (PRBC)
(B) Fresh Frozen Plasma
(C) White Blood Cell concentrates
(D) Pure Fibrinogen powder

108. A transfusion of Packed Red Blood Cells (PRBCs) rather than whole blood is most indicated for a patient suffering from:
(A) A minor superficial cut on the finger
(B) Severe, symptomatic anaemia
(C) Mild to moderate systemic dehydration
(D) An acute common viral fever

109. Which of the following medical conditions cannot possibly be transmitted from donor to recipient through a blood transfusion?
(A) Diabetes Mellitus
(B) Viral Hepatitis B infection
(C) Chronic HIV / AIDS infection
(D) Treponemal Syphilis infection

110. On which date is National Voluntary Blood Donation Day widely observed in India to raise awareness?
(A) January 1
(B) June 14
(C) October 1
(D) December 1

111. What is the scientific term used to describe the physiological process of blood cell formation in the body?
(A) Haemolysis
(B) Haemostasis
(C) Haemorrhage
(D) Haemopoiesis

112. Where are senescent (old and worn-out) red blood cells primarily destroyed and recycled in the human body?
(A) Stomach
(B) Gall bladder
(C) Spleen
(D) Pancreas

113. Because it serves as a major site for the destruction of old erythrocytes, the spleen is commonly referred to in biology as the:
(A) Powerhouse of the blood
(B) Graveyard of RBCs
(C) Blood-brain barrier
(D) Primary pacemaker

114. Which specific type of white blood cell is primarily involved in phagocytosis, actively engulfing and destroying bacterial pathogens?
(A) Eosinophils
(B) Basophils
(C) Lymphocytes
(D) Neutrophils

115. Which of the following constitutes the most abundant type of white blood cell (leukocyte) in normal human blood?
(A) Neutrophils
(B) Lymphocytes
(C) Monocytes
(D) Eosinophils

116. Based on global distribution patterns, which of the following is considered the rarest ABO and Rh blood group combination?
(A) O positive
(B) A positive
(C) AB negative
(D) B positive

117. Read the following statements concerning blood donation awareness programmes:
Statement I: Blood donation camps help ensure a continuous and safe supply of blood for surgeries and trauma care.
Statement II: Creating awareness is necessary because human blood cannot currently be manufactured artificially in factories.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

118. Which specific blood group is statistically the most common across the majority of human populations worldwide?
(A) O negative
(B) AB positive
(C) B negative
(D) O positive

119. The immune response triggered in an Rh-negative mother against her Rh-positive fetus's red blood cells is a classic example of:
(A) Autoimmunity

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59. Are anti-Rh antibodies naturally present in the plasma of a person who has never been exposed to the Rh antigen?
(A) Yes, they are present from birth in all humans.
(B) No, they are only produced after exposure to the Rh antigen.
(C) Yes, they develop spontaneously during adolescence.
(D) No, human bodies are completely incapable of producing anti-Rh antibodies.

60. In medical science, the Rh factor is primarily determined by the presence or absence of which specific antigen?
(A) Antigen A
(B) Antigen D
(C) Antigen B
(D) Antigen O

61. Erythroblastosis fetalis is a severe medical condition that can arise due to incompatibility of the Rh factor between:
(A) An Rh-negative mother and an Rh-positive fetus.
(B) An Rh-positive mother and an Rh-negative fetus.
(C) An Rh-negative mother and an Rh-negative fetus.
(D) An Rh-positive mother and an Rh-positive fetus.

62. Erythroblastosis fetalis typically poses the greatest risk during which pregnancy?
(A) The very initial or first pregnancy of an Rh-negative mother carrying an Rh-positive fetus.
(B) Any gestational pregnancy occurring in a family where the biological father is strictly Rh-negative.
(C) Subsequent pregnancies of an Rh-negative mother carrying an Rh-positive fetus.
(D) The initial or first pregnancy observed in an Rh-positive mother under normal medical conditions.

63. Why does the first Rh-positive child of an Rh-negative mother generally not suffer from erythroblastosis fetalis?
(A) The developing fetus's blood type naturally undergoes a full change to Rh-negative before birth.
(B) The placental barrier completely blocks all maternal nutrients and proteins from reaching the fetus.
(C) The biological father's dominant genetic factors permanently neutralize the fetal Rh antigen in the first child.
(D) Maternal blood lacks sufficient anti-Rh antibodies during the initial first pregnancy.

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64. What standard preventive measure is administered to an Rh-negative mother to prevent Rh incompatibility complications in future pregnancies?
(A) A high dose of Vitamin K shortly after delivery.
(B) A complete blood transfusion of the mother during the first trimester.
(C) An Anti-D (RhoGAM) immunoglobulin injection soon after delivery.
(D) Daily doses of oral iron supplements throughout the pregnancy.

65. Which of the following represents the correct sequence of events leading to erythroblastosis fetalis?
(A) Fetal Rh+ RBCs enter maternal circulation at birth → Maternal immune system produces anti-Rh antibodies → Antibodies cross placenta in next Rh+ pregnancy → Destruction of fetal RBCs
(B) Maternal Rh- RBCs enter fetal circulation → Fetus produces anti-Rh antibodies → Antibodies destroy maternal RBCs → Fetus develops jaundice
(C) Destruction of fetal RBCs → Antibodies cross placenta → Fetal Rh+ RBCs enter maternal circulation → Maternal immune system produces antibodies
(D) Antibodies cross placenta → Fetal Rh+ RBCs enter maternal circulation → Destruction of fetal RBCs → Maternal immune system produces antibodies

66. Read the following statements regarding the prevention of Rh incompatibility:
Statement I: The Anti-D injection must be given to the Rh-negative mother within 72 hours of delivering an Rh-positive baby.
Statement II: The Anti-D injection actively destroys any fetal Rh-positive red blood cells in the mother's circulation before she can become sensitized.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are

ANSWERS

1. (C) 55 percent
Human blood is a specialized fluid connective tissue consisting of cellular elements suspended in a liquid matrix. This liquid extracellular matrix, known as plasma, constitutes approximately fifty-five percent of the total blood volume in a healthy individual. The remaining forty-five percent is composed of formed elements, which include red blood cells, white blood cells, and blood platelets.

2. (D) Erythrocytes
Erythrocytes, commonly referred to as red blood cells, are the most abundant formed elements in human blood. They contain the iron-containing respiratory pigment hemoglobin, which reversibly binds to oxygen molecules in the pulmonary capillaries. These specialized cells transport oxygen efficiently from the lungs to systemic body tissues to support essential metabolic functions and ATP production throughout the body.

3. (A) Fighting infections and providing immunity
White blood cells, scientifically termed leukocytes, serve as the primary defensive agents of the human immune system. They protect the body against pathogens, foreign antigen invasion, and infectious agents through mechanisms such as phagocytosis, antibody secretion, and cell-mediated immune responses. By identifying and neutralizing harmful microbes, white blood cells maintain physiological health and defend against disease.

4. (C) Platelets
Blood platelets, or thrombocytes, are small cell fragments derived from megakaryocytes in the bone marrow. When blood vessels suffer vascular injury, platelets rapidly adhere to the damaged subendothelial tissue, aggregate to form a primary platelet plug, and release essential thromboplastic factors. These actions initiate the complex blood coagulation cascade, preventing excessive blood loss and maintaining vascular integrity.

5. (A) P-3, Q-4, R-1, S-2
Blood components correspond to distinct scientific terminology based on cellular morphology and composition. Red blood cells are designated as erythrocytes due to their red hemoglobin content. White blood cells are classified as leukocytes because of their translucent appearance. Platelets are known as thrombocytes owing to their role in thrombosis, while the fluid portion is termed plasma.

6. (C) 120 days
Mature human erythrocytes lack nuclei and internal cellular organelles, limiting their metabolic repair capabilities over time. Consequently, their average functional lifespan in systemic circulation is approximately one hundred twenty days. After completing this period, aging or damaged red blood cells become structurally fragile and are selectively removed from circulation and broken down by macrophages in the spleen and liver.

7. (B) Fibrinogen is completely absent in blood plasma.
Blood plasma is a straw-colored, slightly alkaline liquid matrix comprising ninety to ninety-two percent water and eight to ten percent dissolved solutes. Crucially, plasma naturally contains major soluble clotting proteins, including fibrinogen, which is synthesized by the liver. Fibrinogen is converted into insoluble fibrin during blood coagulation; its complete absence in normal circulating plasma is a false biological concept.

8. (A) I, II, and III
Mature human red blood cells possess a distinct biconcave disc shape, maximizing surface area for gas diffusion. During maturation, they lose their nuclei to accommodate greater amounts of hemoglobin, the iron-bearing oxygen carrier. While produced in the red bone marrow of healthy adults rather than the spleen, their structural design and protein composition optimize efficient systemic gas exchange.

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the hepatic synthesis of essential blood clotting factors.
(D) Human females completely lack the genetic sequences responsible for synthesizing blood clotting proteins.

77. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A person suffering from severe anaemia often feels fatigued and weak.
Reason (R): Anaemia significantly reduces the oxygen-carrying capacity of the blood to the body's tissues.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

78. Pernicious anaemia is specifically caused by a deficiency of which vitamin in the human body?
(A) Vitamin A
(B) Vitamin C
(C) Vitamin B_{12}
(D) Vitamin D

79. Sickle cell anaemia, a genetic blood disorder, is caused by a structural defect in which molecule?
(A) Fibrinogen
(B) Albumin
(C) Prothrombin
(D) Haemoglobin

80. Read the following statements comparing anaemia and haemophilia:
Statement I: Anaemia can often be treated or managed with dietary changes and iron supplements.
Statement II: Haemophilia is entirely curable with a single dose of iron and vitamins.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

81. Which soluble plasma protein is converted into an insoluble mesh-like network during blood clotting?
(A) Globulin
(B) Fibrinogen
(C) Albumin
(D) Haemoglobin

82. Which vitamin plays an essential role in the synthesis of prothrombin in the liver, thus aiding in blood clotting?
(A) Vitamin E
(B) Vitamin A
(C) Vitamin B6
(D) Vitamin K

83. Which mineral ion is absolutely necessary for multiple steps in the blood coagulation cascade?
(A) Calcium ions (Ca^{2+})
(B) Sodium ions (Na^{+})
(C) Potassium ions (K^{+})
(D) Chloride ions (Cl^{-})

NODIA

84. Arrange the following components in the correct sequence as they function during the blood coagulation process:
I. Fibrin network formation
II. Conversion of Fibrinogen to Fibrin
III. Formation of Prothrombin activator (Thrombokinase)
IV. Conversion of Prothrombin to Thrombin
Which of the following options represents the correct sequence?
(A) III, IV, II, I
(B) I, II, III, IV
(C) IV, III, II, I
(D) III, II, IV, I

85. The solid mass or plug that permanently seals a ruptured blood vessel is primarily held together by threads of:
(A) Fibrin
(B) Thrombin
(C) Heparin
(D) Histamine

86. What is the normal blood clotting time for a healthy human under standard conditions?
(A) 10 to 15 seconds
(B) 2 to 8 minutes
(C) 15 to 30 minutes
(D) 1 to 2 hours

incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

67. What are the severe consequences observed in a fetus suffering from erythroblastosis fetalis?
(A) Severe anaemia and severe jaundice
(B) Accelerated bone growth and high blood pressure
(C) Complete loss of hearing and vision
(D) Immediate failure of the respiratory system without affecting blood cells

68. Can erythroblastosis fetalis occur if the father is Rh-negative and the mother is Rh-positive?
(A) Yes, this medical condition routinely occurs across all successive pregnancies without exception.
(B) Yes, but this clinical complication develops exclusively during the second pregnancy of the couple.
(C) No, because an Rh-positive mother will not produce anti-Rh antibodies against the fetus.
(D) No, because a fetus born to an Rh-positive mother will always inherently be completely Rh-negative.

69. The maternal antibodies that cross the placenta and cause erythroblastosis fetalis belong to which class of immunoglobulins?
(A) IgG
(B) IgA
(C) IgE
(D) IgM

70. Match the pregnancy scenarios in List I with their potential Rh incompatibility risk in List II.
List I: (Pregnancy Scenarios)
P. Mother Rh-, Fetus Rh-
Q. Mother Rh+, Fetus Rh+
R. Mother Rh+, Fetus Rh-
S. Mother Rh-, Fetus Rh+ (Second child)
List II: (Incompatibility Risk)
1. High risk of Erythroblastosis fetalis
2. No risk, mother won't produce antibodies
3. No risk, blood types match (both positive)
4. No risk, blood types match (both negative)
(A) P-4, Q-3, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-2, R-3, S-1
(D) P-3, Q-4, R-1, S-2

71. Anaemia is a common blood disorder primarily characterized by a deficiency of:
(A) Circulating white blood cells
(B) Haemoglobin or red blood cells
(C) Specialized blood platelets
(D) Soluble circulating blood plasma proteins

72. Which specific nutritional deficiency is the most common cause of anaemia in the general population?
(A) Vitamin C deficiency
(B) Calcium deficiency
(C) Iron deficiency
(D) Iodine deficiency

73. Haemophilia is a genetic blood disorder characterized by which primary symptom?
(A) Excessive production of red blood cells leading to thick blood.
(B) Destruction of white blood cells leading to frequent infections.
(C) Abnormal sickle shape of the red blood cells.
(D) Failure of the blood to clot properly after an injury.

74. In terms of genetic inheritance, how is classic haemophilia passed from parents to offspring?
(A) It is an X-linked recessive disorder.
(B) It is an autosomal dominant disorder.
(C) It is an autosomal recessive disorder.
(D) It is a Y-linked dominant disorder.

75. Consider the following features regarding Haemophilia:
I. It is often referred to as the "Royal Disease".
II. A small cut can result in non-stop bleeding.
III. It is caused by the absence or deficiency of certain clotting factors.
IV. It affects females more frequently than males.
Which of the above statements is/are incorrect?
(A) I and II
(B) III only
(C) IV only
(D) I, II, and III

76. Why is haemophilia significantly more common in human males than in females?
(A) Males possess two active X chromosomes in somatic cells, effectively doubling the genetic mutation risk.
(B) Males have a single X chromosome, so one mutated gene causes the disease.
(C) The male Y chromosome actively suppresses

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(C) Neutrophils
(D) Basophils

98. The medical condition characterized by an abnormally low count of circulating red blood cells is clinically termed:
(A) Leukopenia (Low WBC count)
(B) Thrombocytopenia (Low platelets)
(C) Polycythemia (High RBC count)
(D) Erythrocytopenia (Anaemia)

99. In a healthy human adult, the formation of new red blood cells, white blood cells, and platelets primarily occurs in the:
(A) Red bone marrow
(B) Hepatic tissue of the liver
(C) Lymphoid tissue of the spleen
(D) Renal tissue of the kidneys

100. Match the blood component in List I with its clinical significance or related condition in List II.
List I: (Blood Components / Conditions)
P. Low RBC count
Q. Low Platelet count
R. High WBC count
S. Loss of Plasma
List II: (Clinical Significance)
1. Risk of severe hemorrhage (e.g., in Dengue)
2. Indicates an active infection in the body
3. Treated with fluid replacement in severe burns
4. Leads to fatigue and Anaemia
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-2, S-1

101. What is the standard measurement for a normal resting blood pressure in a healthy human adult?
(A) 80/120 mmHg
(B) 100/60 mmHg
(C) 120/80 mmHg
(D) 140/90 mmHg

102. Which specific medical instrument is universally used by healthcare professionals to measure human blood pressure?
(A) Stethoscope
(B) Electrocardiograph
(C) Thermometer
(D) Sphygmomanometer

103. Knowledge of the ABO blood group system can be legally and scientifically applied in which of the following situations?
(A) Determining a person's exact intelligence quotient (IQ)
(B) Solving cases of disputed paternity
(C) Predicting the final height of a child
(D) Curing genetically inherited blindness

104. To maintain viability and prevent bacterial growth, whole blood in a blood bank is strictly stored at which of the following temperature ranges?
(A) -20 to -10 degrees Celsius
(B) 2 to 6 degrees Celsius
(C) 20 to 25 degrees Celsius
(D) 35 to 40 degrees Celsius

105. Read the following statements regarding emergency blood transfusions:
Statement I: In critical emergencies where the recipient's blood group is unknown, O negative blood is often administered to save time.
Statement II: O negative blood is universally safe because it contains large amounts of A, B, and Rh antigens that boost immunity.
Which of the following options is correct?
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct but Statement II is incorrect.
(D) Statement I is incorrect but Statement II is correct.

106. In a modern blood bank setting, what is the primary purpose of a specialized centrifuge machine?
(A) To separate whole blood into packed RBCs, plasma, and platelets.
(B) To rapidly warm up refrigerated cold blood units immediately prior to patient transfusion.
(C) To precisely measure the total quantitative haemoglobin concentration present in a drop of donor blood.
(D) To molecularly detect the presence of transmissible pathogens like the HIV virus in donated blood samples.

107. Which specific blood product is most commonly transfused into patients suffering from life-threatening fluid loss due to severe burns?

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(A) Chronic diabetes mellitus
(B) Essential hypertension
(C) Bronchial asthma
(D) Hepatitis B and HIV

51. The Rh factor was initially discovered in the blood of which animal?
(A) Rhesus monkey
(B) Common chimpanzee
(C) Domestic guinea pig
(D) Standard albino rat

52. Which two scientists are credited with the discovery of the Rh factor?
(A) James Watson, Francis Crick, and Maurice Wilkins
(B) Louis Pasteur, Robert Koch, and Joseph Lister
(C) Karl Landsteiner and Alexander Wiener
(D) Gregor Mendel, Thomas Morgan, and Hugo de Vries

53. If a person is classified as "Rh-positive", what does this specifically mean?
(A) The Rh antigen (Antigen D) is present on their red blood cells.
(B) They possess an exceptionally high count of circulating functional red blood cells.
(C) They possess a complete natural immunity against all common blood-borne pathogens.
(D) Their systemic blood plasma continuously contains naturally occurring anti-Rh antibodies.

54. Approximately what percentage of the global human population is Rh-positive?
(A) 15 percent
(B) 40 percent
(C) 50 percent
(D) 85 percent

55. Match the terms related to the Rh factor in List I with their appropriate descriptions in List II.
List I: (Terms)
P. Rh positive
Q. Rh negative
R. Antigen D
S. Rhesus macaque
List II: (Descriptions)
1. Lacks the Rh antigen on red blood cells
2. The primary protein associated with the Rh factor
3. Has the Rh antigen on red blood cells
4. The primate in which the Rh factor was first identified
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

56. Consider the following statements about an Rh-negative individual:
I. They do not have the Rh antigen on their RBCs.
II. They naturally possess anti-Rh antibodies in their blood from birth.
III. They can safely receive Rh-positive blood multiple times without any reaction.
IV. If exposed to Rh-positive blood, their immune system will produce anti-Rh antibodies.
Which of the above statements are correct?
(A) I and II
(B) III and IV
(C) I and IV
(D) II and III

57. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): An Rh-negative patient should never be repeatedly transfused with Rh-positive blood.
Reason (R): The first transfusion of Rh-positive blood sensitizes the Rh-negative patient, and subsequent transfusions cause severe agglutination.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

58. What happens during the very first instance when an Rh-negative person receives Rh-positive blood?
(A) The recipient's immune system slowly starts producing anti-Rh antibodies.
(B) Immediate and fatal blood clotting occurs within seconds.
(C) The transfused blood automatically converts to Rh-negative blood.
(D) The recipient's circulating red blood cells rapidly change their structural shape to sickle cells.

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(B) Isoimmunization
(C) Innate immunity
(D) Passive immunity

120. What critical biological event will occur if a patient with blood group B accidentally receives a transfusion of blood group A?
(A) The donor's Anti-B antibodies will significantly strengthen and boost the recipient's systemic immune system.
(B) The patient's primary blood group phenotype will permanently change to universal blood group AB within days.
(C) Recipient Anti-A antibodies will attack and clump the donor's Group A red blood cells.
(D) The transfused donor red blood cells will simply dissolve completely and harmlessly into the plasma fluid.

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87. During blood clotting, which active enzyme is directly responsible for converting soluble fibrinogen into insoluble fibrin?
(A) Pepsin
(B) Thrombin
(C) Amylase
(D) Renin

88. Which of the following substances acts as a natural anticoagulant and prevents blood from clotting inside healthy, undamaged blood vessels?
(A) Fibrinogen
(B) Prothrombin
(C) Heparin
(D) Calcium

89. Match the blood clotting elements in List I with their respective roles or types in List II.
List I: (Clotting Elements)
P. Fibrinogen
Q. Calcium
R. Thromboplastin
S. Vitamin K
List II: (Roles / Types)
1. An essential mineral ion for clotting
2. A soluble plasma protein
3. Required for hepatic synthesis of prothrombin
4. Released from injured tissues and platelets
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

90. In a laboratory setting, what happens if calcium ions are completely removed from a freshly drawn blood sample?
(A) The blood will not clot.
(B) The blood will clot almost instantly.
(C) The red blood cells will burst immediately.
(D) The blood will turn completely transparent.

91. The liquid matrix of blood, plasma, constitutes about 55% of the total blood volume. What is the approximate percentage of proteins in this plasma?
(A) 1 to 2 percent
(B) 6 to 8 percent
(C) 20 to 25 percent
(D) 40 to 50 percent

92. What is the clear, yellowish fluid called that is left over after blood has clotted and the clot is removed?
(A) Lymph
(B) Serum
(C) Intracellular fluid
(D) Pus

93. Plasma donation is particularly critical for producing therapies to treat which of the following conditions?
(A) Immune deficiencies and severe burns
(B) Respiratory common cold and minor coughs
(C) Traumatic bone fractures and osteoporosis
(D) Ocular nearsightedness and cataracts

94. Which class of plasma proteins functions primarily as antibodies to combat infectious pathogens?
(A) Albumins
(B) Fibrinogens
(C) Globulins
(D) Lipoproteins

95. What is the major function of the protein albumin, which is abundantly found in human blood plasma?
(A) It directly forms the dense insoluble structural framework of a stabilizing blood clot.
(B) It actively attacks, binds to, and neutralizes circulating viral particles in plasma.
(C) It efficiently transports dissolved molecular oxygen directly to cerebral brain cells.
(D) It maintains colloidal osmotic pressure and plasma fluid balance in blood vessels.

96. Identify the correct statement regarding the difference between blood plasma and blood serum.
(A) Serum contains intact functional red blood cells, whereas plasma is completely devoid of all cellular components.
(B) Plasma is extracted directly from peripheral lymph nodes, whereas serum is filtered exclusively inside the human heart.
(C) Serum is blood plasma lacking its clotting factors like fibrinogen.
(D) There is absolutely no chemical or physiological difference between raw blood plasma and processed blood serum.

97. During a severe infection of Dengue fever, which specific component of the blood drastically decreases in number, posing a high risk of internal bleeding?
(A) Erythrocytes
(B) Platelets

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9. (D) Iron
Hemoglobin is a complex conjugated protein molecule consisting of four polypeptide globin chains, each bound to a prosthetic heme group. At the center of each heme structure resides an iron ion in the ferrous state. This central iron atom reversibly binds oxygen molecules, allowing red blood cells to transport oxygen from pulmonary capillaries to tissue microcirculation.

10. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
White blood cells are frequently characterized as cellular soldiers because they defend the organism against foreign invaders. They perform phagocytosis to engulf bacterial pathogens and synthesize targeted antibodies to neutralize toxic substances and infectious agents. Because these immune defense mechanisms directly protect the body from pathological infections, the descriptive cellular identity is fully justified by their defensive physiological mechanisms.

11. (B) Karl Landsteiner
The ABO blood group system was discovered in the year 1900 by Austrian physician and scientist Karl Landsteiner. His pioneering experiments demonstrated that agglutination reactions occur when serum from one individual is mixed with red blood cells from another. This groundbreaking discovery established the immunological basis for modern blood transfusion safety, earning Landsteiner the Nobel Prize.

12. (B) Specific molecules located on the surface of red blood cells
In blood group serology, antigens are specific surface molecules, primarily glycolipids or glycoproteins, attached to the outer membrane of red blood cells. These molecular markers act as distinct chemical identifiers that interact with specific plasma antibodies. The presence or absence of specific surface antigens determines an individual's blood type within systems such as the ABO and Rh classifications.

13. (A) Blood Group O
Blood classification in the ABO system depends on specific carbohydrate antigens present on erythrocyte membranes. Individuals categorized under blood group O inherit alleles that fail to synthesize either A or B transferase enzymes. As a result, their red blood cells completely lack both A and B antigens on their surface, while their blood plasma naturally contains both anti-A and anti-B antibodies.

14. (C) Neither Anti-A nor Anti-B
Human ABO blood groups follow Landsteiner's rule regarding antigen and antibody distribution. An individual belonging to blood group AB expresses both A and B surface antigens on their red blood cells. Consequently, their blood plasma lacks both anti-A and anti-B antibodies, preventing self-agglutination and allowing their plasma to tolerate red cells displaying either antigen without triggering immune destruction.

15. (A) P-3, Q-4, R-1, S-2
Blood group phenotypes directly reflect the presence of specific surface antigens on erythrocytes. Blood group A displays only antigen A, whereas blood group B displays exclusively antigen B. Blood group AB expresses both antigen A and antigen B simultaneously on the red cell membrane. Conversely, blood group O is defined by the complete absence of both A and B antigens.

16. (B) In the blood plasma
Antibodies of the ABO blood group system, designated as anti-A and anti-B isoagglutinins, are dissolved immunoglobulins circulating within the liquid blood plasma. Unlike surface-bound antigens located on erythrocyte membranes, these plasma antibodies are produced by immune cells in response to environmental cross-reactive antigens and interact specifically with foreign erythrocyte antigens during incompatible blood transfusion events.

17. (D) O negative
Individuals with O negative blood are recognized as universal red cell donors because their red blood cells completely lack A, B, and Rh (D) surface antigens. Consequently, transfusing these erythrocytes into recipients of any ABO or Rh blood group minimizes the risk of triggering an immediate immune reaction or agglutination caused by pre-existing recipient plasma antibodies.

18. (A) AB positive
Individuals with AB positive blood type are considered universal recipients for red blood cell transfusions. Their red blood cells express antigen A, antigen B, and the Rh factor, meaning their circulating plasma contains no anti-A, anti-B, or

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mutated allele results in disease expression. Females require two mutated X alleles to manifest the disorder, making clinical hemophilia predominantly male.

75. (C) IV only
Hemophilia is historically termed the "Royal Disease" due to its prevalence in European royal families and is caused by missing essential blood clotting factors, leading to continuous bleeding from small cuts. Because it is an X-linked recessive disorder, hemophilia overwhelmingly affects males rather than females, rendering the statement regarding female prevalence incorrect.

76. (B) Males have a single X chromosome, so one mutated gene causes the disease.
Hemophilia displays a higher incidence in human males due to its X-linked recessive inheritance pattern. Males possess a hemizygous sex chromosome constitution consisting of one X chromosome and one Y chromosome. Consequently, carrying a single mutated gene on the X chromosome results in disease expression, whereas females are typically asymptomatic carriers unless homozygous for the mutation.

77. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Individuals suffering from anemia frequently experience chronic fatigue, lethargy, and muscular weakness. This occurs because low hemoglobin levels or reduced red cell counts significantly impair the oxygen-carrying capacity of systemic blood. Deficient oxygen delivery to peripheral tissues and organs compromises cellular respiration and ATP production, explaining the physiological basis of these characteristic symptoms.

78. (C) Vitamin B_{12}
Pernicious anemia is a specific form of megaloblastic anemia caused by severe deficiency of Vitamin B_{12}, often resulting from impaired production of intrinsic factor by stomach parietal cells. Vitamin B_{12} is essential for DNA synthesis during erythrocyte maturation in bone marrow; its deficiency leads to abnormal, enlarged red blood cells and progressive neurological damage.

79. (D) Haemoglobin
Sickle cell anemia is an autosomal recessive genetic blood disorder caused by a single point mutation in the beta-globin gene of hemoglobin, producing abnormal Hemoglobin S. Under low oxygen tension, Hemoglobin S molecules polymerize into rigid fibrous rods, distorting flexible round red blood cells into rigid, crescent, or sickle-shaped structures that obstruct capillary blood flow.

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80. (C) Statement I is correct but Statement II is incorrect.
Nutritional anemias can effectively be treated or managed through iron supplementation and dietary modifications. Conversely, hemophilia is a lifelong genetic coagulation disorder caused by hereditary deficiencies in specific clotting factor proteins. It cannot be cured by taking iron or vitamins, requiring factor replacement therapy or advanced medical management to control bleeding episodes.

81. (B) Fibrinogen
Fibrinogen is a high-molecular-weight soluble glycoprotein synthesized by the liver and suspended in blood plasma. During the final stage of the blood coagulation cascade, the active proteolytic enzyme thrombin cleaves fibrinogen into insoluble fibrin monomers. These monomers rapidly polymerize into an insoluble fibrous protein meshwork that traps blood cells and stabilizes the blood clot.

82. (D) Vitamin K
Vitamin K is an essential fat-soluble nutrient that acts as an indispensable cofactor for the hepatic enzyme gamma-glutamyl carboxylase. This enzyme modifies key blood coagulation factors, including prothrombin (Factor II), Factor VII, Factor IX, and Factor X. Without adequate Vitamin K, the liver cannot produce functional clotting proteins, resulting in impaired coagulation and bleeding tendencies.

83. (A) Calcium ions (Ca_2+)
Ionized calcium plays a critical, irreplaceable role as Factor IV throughout both the intrinsic and extrinsic pathways of the blood coagulation cascade. Calcium ions enable the assembly of clotting enzyme complexes on phospholipid membranes, facilitating the activation of prothrombin to thrombin and the subsequent conversion of fibrinogen to fibrin during blood clot formation.

84. (A) III, IV, II, I
Blood coagulation proceeds through a sequential enzymatic cascade. Vascular injury triggers tissue

matching, and identifying potential transfusion incompatibilities.

28. (B) Codominance
AB blood group inheritance exemplifies codominance, a genetic condition where two different alleles of a single gene are fully expressed simultaneously in a heterozygous individual. Neither the IA allele nor the IB allele masks the expression of the other. Consequently, both A and B sugar antigens are produced on the red blood cell surface, displaying both parental phenotypic traits together.

29. (A) Blood Group A
An individual carrying the homozygous genotype IA IA possesses two copies of the allele responsible for producing N-acetylgalactosaminyltransferase. This enzyme adds A-antigens to the surface of red blood cells. Because no IB allele is present and the IA allele is fully expressed, the red cells exclusively display antigen A, resulting in the expression of blood group A phenotype.

30. (A) P-3, Q-1, R-2, S-4
Specific genotypes within the ABO system directly determine individual blood phenotypes. The heterozygous genotype IA i produces blood group A because allele IA dominates allele i. The homozygous recessive genotype ii yields blood group O. The heterozygous genotype IA IB exhibits codominance, resulting in blood group AB, whereas the genotype IB i produces blood group B.

31. (D) The intravenous transfer of blood or blood components into a recipient's circulation.
A blood transfusion is a standard medical procedure in which donated whole blood or specific blood components, such as red blood cells, plasma, or platelets, are intravenously administered directly into a patient's bloodstream. This life-saving intervention restores circulating volume, improves tissue oxygenation, or restores missing coagulation factors lost due to injury, surgery, or medical conditions.

32. (C) Agglutination and destruction of transfused red cells blocking critical blood vessels.
Transfusing ABO-incompatible blood triggers a severe acute hemolytic transfusion reaction. Pre-existing antibodies in the recipient's plasma immediately bind to foreign antigens on donor erythrocytes, causing massive intravascular agglutination and complement-mediated hemolysis. Clumped red cells obstruct microvascular networks, leading to systemic organ failure, severe renal failure, disseminated intravascular coagulation, and potentially fatal shock in the recipient.

33. (B) Both the ABO blood group and the Rh factor.
Prior to performing any blood transfusion, clinical protocol mandates rigorous compatibility testing of both the ABO blood group and the Rh factor for donor and recipient. Verifying both systems prevents severe immunological reactions caused by pre-existing or inducible antibodies against major erythrocyte surface antigens, ensuring maximum patient safety and preventing life-threatening hemolytic transfusion complications.

34. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Individuals with O negative blood are categorized as universal donors in emergency medicine. Their red blood cells completely lack A, B, and Rh (D) surface antigens. Consequently, these red cells will not react with anti-A, anti-B, or anti-Rh antibodies in a recipient's plasma, minimizing the danger of acute immune agglutination during urgent transfusions.

35. (A) A person with group B can safely receive blood from a group AB donor.
A person belonging to blood group B naturally possesses circulating anti-A antibodies in their plasma. Transfusing blood from a group AB donor introduces red cells carrying antigen A on their membranes. Recipient anti-A antibodies will immediately target and clump these donor erythrocytes, making transfusing group AB blood into a group B individual medically unsafe and contraindicated.

36. (C) Group B and Group O only
A patient with blood group B has surface antigen B on their erythrocytes and circulating anti-A antibodies in their plasma. During transfusion therapy, this patient can safely receive red blood cells from matching group B donors or universal group O donors, as neither contains antigen A. Blood from group A or AB would trigger dangerous immune destruction.

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37. (A) The collection and reinfusion of a patient's own blood.
An autologous blood transfusion involves collecting, processing, and storing a patient's own blood prior to an elective surgical procedure, followed by reinfusing it into the same individual when needed. This medical practice eliminates risks of allogeneic disease transmission, allergic reactions, and immunological blood group incompatibilities, providing a highly safe option for surgical blood replacement.

38. (C) 35 to 42 days
In modern blood banking, donated whole blood collected in approved anticoagulant-preservative solutions, such as Citrate Phosphate Dextrose Adenine, is stored under strict refrigeration between two and six degrees Celsius. Under these standardized cold conditions, whole blood and packed red blood cell units remain viable for therapeutic transfusion for a maximum duration of thirty-five to forty-two days.

39. (B) Sodium citrate
Sodium citrate is widely utilized as an effective anticoagulant in blood donation collection bags and laboratory storage tubes. It functions by chelating free ionized calcium present in blood plasma. Because calcium ions are essential cofactors for multiple enzymatic steps in the coagulation cascade, binding these ions effectively prevents clotting, keeping stored whole blood fluid and functional.

40. (A) P-4, Q-1, R-3, S-2
Transfusion compatibility depends on matching recipient plasma antibodies with donor red cell antigens. Recipient blood group A receives blood from A and O. Recipient blood group B receives blood from B and O. Recipient blood group AB lacks major isoagglutinins and receives from A, B, AB, and O, while recipient blood group O receives exclusively from O.

41. (B) 18 years
Medical standards and blood transfusion guidelines mandate that voluntary blood donors must be at least eighteen years of age. This regulatory age threshold ensures that donors have attained complete physiological maturity, adequate total blood volume, and full legal capacity to provide informed consent, protecting donor health while maintaining ethical standards in voluntary blood donation programs.

42. (B) 45 kg
Standard medical guidelines require a voluntary donor to weigh at least forty-five kilograms before donating blood. This baseline weight criterion ensures that drawing a standard volume of blood does not exceed ten percent of the donor's total blood volume. Adhering to this threshold prevents donor hypotension, vasovagal syncope, and post-donation fatigue or circulatory impairment.

43. (C) I, II, and IV
Safe blood donation requires strict adherence to eligibility criteria to safeguard both donor and recipient. Eligible donors must exhibit normal body temperature and pulse rates, abstain from alcohol consumption for twenty-four hours prior to donation, and maintain hemoglobin levels above twelve point five grams per deciliter. Individuals suffering from active viral fevers are temporarily deferred from donating.

44. (B) 3 months
Healthy adult males are advised to observe a minimum time interval of three months, or ninety days, between consecutive whole blood donations. This physiological recovery period allows the bone marrow sufficient time to replenish depleted iron reserves and fully synthesize replacement red blood cells, preventing iron deficiency anemia and maintaining long-term donor health and vitality.

45. (B) 350 to 450 ml
During a standard voluntary donation session, blood banks safely collect approximately three hundred fifty to four hundred fifty milliliters of whole blood from an adult donor. This calibrated volume represents less than ten percent of an average adult's total blood volume, allowing rapid physiological fluid restoration without compromising cardiovascular stability or causing adverse hemodynamic side effects.

46. (C) Donating blood causes permanent physical weakness and long-term immunity loss.
The belief that donating blood leads to permanent physical weakness or long-term loss of immunity is a widespread misconception. In healthy individuals, lost plasma volume is restored within twenty-four to forty-eight hours, while red blood cells are fully regenerated by the bone marrow over several weeks without causing

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lasting fatigue or damaging immune defense capabilities.

47. (D) To collect, test, process, and safely store donated human blood.
Blood banks serve as essential medical facilities dedicated to the recruitment of voluntary donors, collection of blood, rigorous infectious disease screening, and processing into specific components like plasma and platelets. They ensure proper preservation under regulated temperature conditions and maintain a safe, continuous supply of compatible blood products for emergency trauma care, surgeries, and chronic therapies.

48. (C) 12.5 g/dL
Blood donation safety regulations specify that prospective donors must demonstrate a minimum hemoglobin concentration of twelve point five grams per deciliter. Pre-donation screening confirms that donating a unit of blood will not induce anemia or physiological fatigue in the donor, while ensuring that transfused blood units contain adequate hemoglobin concentrations to benefit recipients effectively.

49. (A) IV, III, I, II
Standard voluntary blood donation follows an established sequence. First, the prospective donor completes registration and consent forms. Next, healthcare personnel conduct medical screening and perform a hemoglobin test. Once cleared, phlebotomy is performed using sterile, single-use equipment to collect blood. Finally, the donor rests and receives post-donation refreshments to ensure full circulatory recovery.

50. (D) Hepatitis B and HIV
To prevent transfusion-transmitted infections, regulatory authorities mandate mandatory screening of every collected blood unit for high-risk pathogens. Testing screens for blood-borne viruses, specifically including Hepatitis B virus, Hepatitis C virus, and Human Immunodeficiency Virus, alongside syphilis and malaria. Screening guarantees that transfused blood products are safe and free from life-threatening infectious disease agents.

51. (A) Rhesus monkey
The Rh blood group factor was originally identified in 1940 during laboratory research involving the blood of the Rhesus monkey, scientifically named Macaca mulatta. Researchers discovered that red blood cells from these primates carried a surface protein that stimulated antibody production in experimental animals, revealing an identical antigen present on human erythrocytes.

52. (C) Karl Landsteiner and Alexander Wiener
The discovery of the Rh factor in 1940 is attributed to Austrian-American scientist Karl Landsteiner and American physician Alexander Wiener. Through joint immunological investigations on Rhesus monkey erythrocytes, they identified the Rh antigen on human red blood cells, significantly advancing transfusion medicine and providing an explanation for hemolytic disease of the newborn.

53. (A) The Rh antigen (Antigen D) is present on their red blood cells.
An individual classified as Rh-positive possesses the specific cell-surface protein antigen known as Antigen D attached to their red blood cell membranes. This major surface antigen is inherited as a dominant genetic trait. Individuals expressing Antigen D do not produce anti-Rh antibodies under normal physiological conditions, making them compatible with Rh-positive blood.

54. (D) 85 percent
Across global human populations, approximately eighty-five percent of individuals inherit the dominant genetic factors responsible for expressing the Rh antigen on their erythrocytes, classifying them as Rh-positive. The remaining fifteen percent lack this surface protein and are designated as Rh-negative, though exact population frequencies vary slightly among different ethnic and geographic groups worldwide.

55. (A) P-3, Q-1, R-2, S-4
Terms associated with the Rh system describe distinct biological entities. Rh-positive indicates the presence of Rh surface antigens on erythrocytes, whereas Rh-negative denotes their complete absence. Antigen D represents the primary immunogenic protein responsible for Rh classification, and the Rhesus macaque is the non-human primate species in which this blood factor was originally discovered.

56. (C) I and IV
Rh-negative individuals lack the Rh surface antigen on their red blood cells and do not naturally possess anti-Rh antibodies in their

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plasma at birth. However, if exposed to Rh-positive red blood cells through an incompatible transfusion or pregnancy, their immune system becomes sensitized and synthesizes specific anti-Rh antibodies against the foreign D antigen.

57. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Transfusing Rh-positive blood into an Rh-negative patient must strictly be avoided, especially repeatedly. Initial exposure to foreign D antigens sensitizes the recipient's immune system, initiating anti-Rh antibody production. Subsequent transfusions of Rh-positive blood trigger rapid antigen-antibody reactions, leading to extensive red cell agglutination, intravascular hemolysis, and life-threatening systemic transfusion complications.

58. (A) The recipient's immune system slowly starts producing anti-Rh antibodies.
When an Rh-negative individual receives a first transfusion of Rh-positive blood, immediate severe agglutination usually does not occur because pre-existing anti-Rh antibodies are absent. Instead, exposure to foreign D antigens sensitizes the recipient's immune system, initiating a primary immune response that slowly synthesizes specific anti-Rh antibodies over subsequent weeks, creating immunological memory.

59. (B) No, they are only produced after exposure to the Rh antigen.
Unlike ABO system isoagglutinins, anti-Rh antibodies are not naturally present in human blood plasma at birth. An Rh-negative individual's plasma remains entirely free of anti-Rh antibodies until their immune system encounters the foreign Rh (D) antigen through parenteral exposure, such as an incompatible blood transfusion or fetomaternal hemorrhage during pregnancy.

60. (B) Antigen D
Within the Rh blood group system, clinical Rh positivity or negativity is primarily determined by the presence or absence of a single cell-surface protein designated as Antigen D. Because Antigen D exhibits high immunogenicity, testing for this specific antigen on red blood cells is essential during blood donor screening and pre-transfusion matching.

61. (A) An Rh-negative mother and an Rh-positive fetus.
Erythroblastosis fetalis, also known as hemolytic disease of the newborn, develops due to Rh factor incompatibility between an Rh-negative mother and her Rh-positive fetus. Maternal anti-Rh antibodies produced during prior sensitization cross the placental barrier into fetal circulation, binding to fetal Rh-positive red cells and causing immune-mediated cell destruction and severe fetal anemia.

62. (C) Subsequent pregnancies of an Rh-negative mother carrying an Rh-positive fetus.
Erythroblastosis fetalis primarily threatens second or subsequent pregnancies in an Rh-negative mother carrying an Rh-positive fetus. Sensitization usually occurs during delivery of the first Rh-positive child when fetal blood enters maternal circulation. High levels of maternal IgG anti-Rh antibodies developed after this initial exposure cross the placenta in subsequent pregnancies, attacking fetal red cells.

63. (D) Maternal blood lacks sufficient anti-Rh antibodies during the initial first pregnancy.
During a first pregnancy, fetal Rh-positive red blood cells remain separated from maternal circulation by the intact placental barrier. Significant fetomaternal hemorrhage typically occurs only during labor and delivery. Consequently, an Rh-negative mother lacks pre-existing anti-Rh antibodies during her first pregnancy, allowing the initial Rh-positive fetus to develop and be born unaffected by hemolysis.

64. (C) An Anti-D (RhoGAM) immunoglobulin injection soon after delivery.
To prevent maternal sensitization and Rh incompatibility in future pregnancies, an Rh-negative mother delivering an Rh-positive infant is administered an Anti-D immunoglobulin injection. Administered within seventy-two hours post-delivery, these exogenous antibodies rapidly clear circulating fetal Rh-positive red blood cells from maternal blood before her immune system can recognize them and synthesize anti-Rh antibodies.

65. (A) Fetal Rh+ RBCs enter maternal circulation at birth → Maternal immune system produces anti-Rh antibodies → Antibodies cross placenta

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in next Rh+ pregnancy → Destruction of fetal RBCs
Erythroblastosis fetalis follows a specific cascade of immunological events. Fetal Rh-positive red cells enter maternal circulation during delivery, stimulating the mother's immune system to synthesize anti-Rh antibodies. In a subsequent Rh-positive pregnancy, maternal IgG antibodies cross the placenta, enter fetal circulation, and bind to fetal erythrocytes, causing extensive hemolysis and hemolytic disease.

66. (A) Both Statement I and Statement II are correct.
Administering Anti-D immunoglobulin to an Rh-negative mother within seventy-two hours of delivering an Rh-positive child is a highly effective preventive protocol. The injected antibodies bind to and destroy fetal Rh-positive erythrocytes circulating in maternal blood before her immune system detects the foreign D antigen, successfully preventing active maternal immunization and protecting future pregnancies.

67. (A) Severe anaemia and severe jaundice
In erythroblastosis fetalis, maternal anti-Rh antibodies cause widespread destruction of fetal red blood cells, resulting in profound fetal anemia. Rapid breakdown of hemoglobin releases massive quantities of bilirubin, exceeding the immature liver's metabolic capacity and causing severe neonatal jaundice. If untreated, severe cases can lead to hydrops fetalis, brain damage, or fetal death.

68. (C) No, because an Rh-positive mother will not produce anti-Rh antibodies against the fetus.
Erythroblastosis fetalis cannot occur when the mother is Rh-positive, regardless of the father's Rh status. Because the mother already possesses the Rh antigen on her own red blood cells, her immune system recognizes the D antigen as self and will not produce anti-Rh antibodies, ensuring that fetal erythrocytes are not targeted for immune destruction.

69. (A) IgG
The maternal anti-Rh antibodies responsible for causing erythroblastosis fetalis belong to the Immunoglobulin G class. Unlike larger IgM antibodies, monomeric IgG molecules actively cross the placental syncytiotrophoblast barrier via specialized receptor-mediated transport. Once in fetal blood, these maternal IgG antibodies attach to fetal Rh-positive erythrocytes, triggering immune-mediated hemolysis and fetal anemia.

70. (A) P-4, Q-3, R-2, S-1
Rh incompatibility risks depend on maternal-fetal blood combinations. An Rh-negative mother with an Rh-negative fetus presents no risk due to matching types. Rh-positive mothers carrying Rh-positive or Rh-negative fetuses present no risk because the mother does not synthesize anti-Rh antibodies. Conversely, an Rh-negative mother carrying a second Rh-positive fetus carries a high risk of erythroblastosis fetalis.

71. (B) Haemoglobin or red blood cells
Anemia is a common blood disorder characterized by a quantitative decrease in circulating red blood cells or a reduction in total hemoglobin concentration below normal physiological levels. This deficiency impairs the oxygen-carrying capacity of blood, reducing tissue oxygenation and leading to symptoms such as fatigue, generalized weakness, paleness, and shortness of breath during exertion.

72. (C) Iron deficiency
Iron deficiency represents the single most prevalent cause of anemia worldwide. Iron is an essential component required for the hepatic and erythroid synthesis of heme in hemoglobin. Insufficient dietary iron intake, poor intestinal absorption, or chronic blood loss depletes body iron stores, inhibiting erythrocyte production and yielding microcytic, hypochromic red blood cells.

73. (D) Failure of the blood to clot properly after an injury.
Hemophilia is a rare hereditary bleeding disorder characterized by the body's inability to form stable blood clots following vascular injury. Affected individuals suffer from deficiencies in specific plasma clotting proteins, such as Factor VIII or Factor IX. Consequently, even minor cuts, injuries, or surgical procedures can cause prolonged, uncontrolled external or internal bleeding.

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74. (A) It is an X-linked recessive disorder.
Classic hemophilia is inherited as an X-linked recessive genetic trait caused by mutations in genes located on the X chromosome that encode blood clotting factors. Because males possess only one X chromosome, inheriting a single

94. (C) Globulins
Globulins represent a key class of blood plasma proteins, subdivided into alpha, beta, and gamma globulins. Gamma globulins, commonly designated as immunoglobulins or antibodies, are synthesized by plasma cells. They specifically recognize, bind to, and neutralize foreign bacterial and viral antigens, providing essential humoral immune protection against infectious diseases throughout the body.

95. (D) It maintains colloidal osmotic pressure and plasma fluid balance in blood vessels.
Albumin is the most abundant plasma protein synthesized by the liver, accounting for approximately sixty percent of total plasma protein content. Its primary physiological function is maintaining plasma colloid osmotic pressure, preventing excess fluid from leaking out of capillaries into surrounding interstitial tissues. Additionally, albumin acts as a carrier protein for hormones, fatty acids, and drugs.

96. (C) Serum is blood plasma lacking its clotting factors like fibrinogen.
The key biochemical distinction between blood plasma and blood serum lies in the presence of coagulation proteins. Blood plasma is the unclotted fluid component containing active clotting factors, including soluble fibrinogen. Serum is the liquid portion obtained after blood has fully clotted; hence, serum is defined as blood plasma depleted of fibrinogen and consumed clotting factors.

97. (B) Platelets
Severe Dengue fever infection often induces significant bone marrow suppression and immune-mediated destruction of circulating blood platelets, a condition known as thrombocytopenia. Because platelets are essential for maintaining vascular endothelial integrity and initiating primary blood clotting, a drastic drop in platelet count increases the risk of severe internal hemorrhaging and plasma leakage in dengue patients.

98. (D) Erythrocytopenia (Anaemia)
Erythrocytopenia is the medical term used to describe an abnormally low concentration of circulating red blood cells in the body. Because erythrocytes contain oxygen-binding hemoglobin, a deficiency in red cell numbers reduces the oxygen-carrying capacity of blood. This condition is clinically referred to as anemia, leading to systemic tissue hypoxia, fatigue, and pale skin.

99. (A) Red bone marrow
In healthy human adults, the primary anatomical site for hematopoiesis—the continuous generation of blood cells—is the red bone marrow. Located inside the cavities of axial bones, such as the sternum, ribs, vertebrae, and pelvis, hematopoietic stem cells within the red bone marrow continuously divide and differentiate into erythrocytes, leukocytes, and blood platelets.

100. (A) P-4, Q-1, R-2, S-3
Blood conditions correspond to distinct clinical manifestations. A low red blood cell count leads to fatigue and anemia due to reduced oxygen transport. A low platelet count increases the risk of severe hemorrhage, as seen in Dengue. An elevated white blood cell count indicates an active infection, while plasma loss in severe burns requires fluid replacement therapy.

101. (C) 120/80 mmHg
In a healthy human adult at rest, normal systemic blood pressure is standardly measured at 120/80 mmHg. The higher value, 120 mmHg, represents systolic blood pressure exerted during ventricular contraction, while the lower value, 80 mmHg, reflects diastolic blood pressure during ventricular relaxation, expressed in millimeters of mercury above atmospheric pressure.

102. (D) Sphygmomanometer
A sphygmomanometer is the standard medical instrument utilized by healthcare professionals to measure arterial blood pressure. Comprising an inflatable rubber cuff, a pressure gauge, and a inflation bulb, it measures systolic and diastolic pressure in millimeters of mercury, often used alongside a stethoscope to detect brachial artery Korotkoff sounds during cuff deflation.

103. (B) Solving cases of disputed paternity
Understanding the genetic inheritance patterns of the ABO blood group system is applied in forensic medicine and legal proceedings to resolve cases of disputed paternity. Because ABO blood types follow predictable Mendelian codominance rules, comparing the blood groups of a mother, child, and alleged father can conclusively exclude a man from biological paternity.

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factor release, leading to the formation of the prothrombin activator complex (thrombokinase). Prothrombin activator converts inactive plasma prothrombin into active thrombin. Thrombin then enzymatically cleaves soluble fibrinogen into insoluble fibrin, which polymerizes to form a dense fibrous network that stabilizes the clot.

85. (A) Fibrin
The permanent structural plug that seals damaged blood vessels during hemostasis relies on long, insoluble threads of fibrin. Active thrombin converts soluble plasma fibrinogen into fibrin monomers, which polymerize and cross-link to form an entangled molecular web. This mesh entrains blood platelets and circulating erythrocytes, solidifying into a durable hemostatic clot over damaged vascular walls.

86. (B) 2 to 8 minutes
Blood clotting time measures the physiological period required for drawn unanticoagulated blood to form a firm, insoluble fibrin clot. In a healthy human individual under standard clinical laboratory conditions, normal clotting time ranges between two and eight minutes. Prolonged clotting times indicate underlying deficiencies in plasma coagulation factors, Vitamin K, or blood platelets.

87. (B) Thrombin
Thrombin, also designated as activated Factor II, is a key serine protease enzyme in the coagulation cascade. It is generated from inactive plasma prothrombin through the action of the prothrombinase complex. Once formed, thrombin directly catalyzes the proteolytic conversion of soluble plasma fibrinogen into insoluble fibrin monomers, initiating structural blood clot stabilization.

88. (C) Heparin
Heparin is a naturally occurring sulfated glycosaminoglycan produced by basophils and tissue mast cells that acts as a potent endogenous anticoagulant. It binds to antithrombin III, accelerating its inhibition of active thrombin and Factor Xa. This physiological mechanism prevents intravascular thrombosis, keeping circulating blood fluid inside normal, healthy blood vessels throughout the body.

89. (A) P-2, Q-1, R-4, S-3
Elements involved in blood coagulation perform specific physiological functions. Fibrinogen is a soluble plasma protein that forms the clot matrix. Calcium serves as an essential mineral ion required for enzyme activations. Thromboplastin is released from damaged tissues and platelets to initiate coagulation, while Vitamin K is required for the hepatic synthesis of prothrombin.

90. (A) The blood will not clot.
Calcium ions act as essential cofactors across multiple steps of both intrinsic and extrinsic coagulation pathways. Completely removing or chelating ionized calcium from a freshly drawn blood sample inhibits the enzymatic conversion of prothrombin to thrombin and fibrinogen to fibrin. Without active calcium ions present, the complex coagulation cascade stops entirely, preventing blood clotting.

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91. (B) 6 to 8 percent
Blood plasma is a liquid extracellular matrix comprising approximately fifty-five percent of total blood volume. Water accounts for ninety to ninety-two percent of plasma volume, while dissolved proteins constitute approximately six to eight percent. These major plasma proteins include albumins, globulins, and fibrinogen, which perform vital osmotic, immunological, and hemostatic functions within the body.

92. (B) Serum
Blood serum is the pale yellow, clear fluid that remains after whole blood has undergone complete coagulation and the insoluble clot has been physically separated. Compositionally, serum is essentially identical to blood plasma, except that it lacks cellular elements, fibrinogen, and other coagulation factors consumed during the formation of the fibrin blood clot.

93. (A) Immune deficiencies and severe burns
Donated blood plasma is a critical resource used to produce specialized life-saving therapies. Plasma contains essential proteins, including immunoglobulins and albumin. Plasma-derived immunoglobulins provide vital passive antibody therapy for patients with primary immunodeficiency diseases, while albumin transfusions restore critical blood volume, colloid osmotic pressure, and fluid balance in patients suffering from severe burn injuries.

anti-Rh antibodies. As a result, their immune system will not attack or agglutinate transfused erythrocytes from any standard ABO or Rh donor type.

19. (C) C
The human ABO blood group system is defined by three primary alleles: IA, IB, and i, which determine four standard phenotypic blood groups. These recognized phenotypes are blood group A, blood group B, blood group AB, and blood group O. Blood phenotype C does not exist within the human ABO classification system, representing an invalid blood type designation in medical genetics.

20. (A) Both Statement I and Statement II are correct.
The inheritance of human ABO blood groups provides a classic biological example of multiple allelism. A single gene located on chromosome 9, denoted as gene I, possesses three distinct alleles in the human population: IA, IB, and i. These three alleles interact through dominant, codominant, and recessive inheritance patterns to produce the four human blood group phenotypes.

21. (C) 6
Human ABO blood groups are determined by three distinct alleles of a single gene: IA, IB, and i. Because human cells are diploid, combining any two of these three alleles generates six possible genetic combinations. These six genotypes—IA IA, IA i, IB IB, IB i, IA IB, and ii—give rise to the four distinct blood phenotypes observed in human populations.

22. (D) ii
Blood group O phenotype is inherited as a recessive trait in the ABO blood group system. The allele designated as i is recessive to both IA and IB alleles and does not produce functional glycosyltransferase enzymes. Therefore, an individual exhibits blood group O only when homozygous for the recessive allele, resulting in the specific homozygous genotype designated as ii.

23. (C) III only
The inheritance of allele IA and allele IB demonstrates codominance rather than incomplete dominance. Both IA and IB alleles are completely dominant over the recessive allele i. When IA and IB are present together in a heterozygous individual, both alleles express their respective surface antigens fully and independently, resulting in the AB blood phenotype rather than an intermediate blended expression pattern.

24. (C) Mother IA i, Father IB i
A child displaying blood group O must possess the homozygous recessive genotype ii, inheriting one recessive allele i from each parent. For a mother with blood group A and a father with blood group B to produce a group O child, both parents must be heterozygous carriers, possessing the genotypes IA i and IB i respectively, supplying the necessary recessive alleles.

25. (B) Prick finger to collect blood → Add Anti-A and Anti-B sera to separate blood drops → Mix well → Observe for agglutination
Standard laboratory blood typing follows a precise procedural sequence to ensure safety and diagnostic accuracy. The clinician first sanitizes and pricks the finger to obtain fresh blood drops on a glass slide. Commercial Anti-A and Anti-B antisera are then added to separate drops, thoroughly mixed using clean applicators, and systematically observed for visible erythrocyte agglutination to determine blood type.

26. (A) Agglutination or clumping of the red blood cells occurs.
Serological blood typing relies on specific antigen-antibody binding reactions. When commercial antiserum containing specific antibodies is mixed with red blood cells carrying the corresponding surface antigen, cross-linking occurs between the cells. This immunological binding causes red blood cells to aggregate into visible macroscopic clumps, a diagnostic phenomenon known as agglutination, which confirms the presence of that specific antigen.

27. (B) It occurs when specific antigens and corresponding antibodies react to form clumps.
Blood agglutination is an immunological reaction characterized by the clumping together of red blood cells. It occurs when surface antigens on erythrocytes bind specifically with corresponding antibodies circulating in blood plasma or antiserum. This cross-linking process forms a meshwork of clumped cells, which is clinically significant in blood typing, cross-

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104. (B) 2 to 6 degrees Celsius
Collected whole blood and packed red blood cell units stored in blood banks must strictly be maintained within a refrigerated temperature range of two to six degrees Celsius. This controlled cold environment slows erythrocyte cellular metabolism, preserves glucose concentration, inhibits bacterial growth, and maintains red cell viability and functional stability throughout the permitted storage period.

105. (C) Statement I is correct but Statement II is incorrect.
In critical emergency situations where a patient's blood type cannot be immediately determined, O negative uncrossmatched red blood cells are transfused to prevent fatal blood loss. O negative blood is considered safe not because it contains antigens, but because its erythrocytes lack A, B, and Rh antigens, preventing acute antigen-antibody hemolysis.

106. (A) To separate whole blood into packed RBCs, plasma, and platelets.
In modern blood centers, specialized refrigerated centrifuges are utilized to separate whole blood into individual therapeutic components based on relative cell density. High-speed spinning separates collected whole blood into concentrated packed red blood cells, platelet-rich plasma, and cell-free plasma, allowing patients to receive specific blood components tailored to their medical needs.

107. (B) Fresh Frozen Plasma
Severe burn injuries destroy microvascular barriers, causing extensive leakage of plasma proteins and extracellular fluid from the circulation. Transfusing Fresh Frozen Plasma is critical in treating severe burn patients because it rapidly restores intravascular fluid volume, replenishes essential plasma proteins like albumin, and maintains colloidal osmotic pressure, preventing hypovolemic shock and tissue edema.

108. (B) Severe, symptomatic anaemia
A transfusion of Packed Red Blood Cells is specifically indicated for patients suffering from severe, symptomatic anemia or acute surgical blood loss. Administering concentrated red cells increases hemoglobin concentration and tissue oxygen-carrying capacity directly without overloading the patient's circulatory system with excess plasma volume, reducing the risk of transfusion-associated circulatory overload.

109. (A) Diabetes Mellitus
Diabetes Mellitus is a non-communicable metabolic disorder characterized by chronic hyperglycemia caused by defects in insulin secretion or insulin action. Because it is a metabolic disease rather than an infectious pathogen-driven illness, Diabetes Mellitus cannot be transmitted from a donor to a recipient through blood transfusion or plasma infusion procedures.

110. (C) October 1
In India, National Voluntary Blood Donation Day is celebrated annually on October 1st. Established in 1975 by the Indian Society of Blood Transfusion and Immunohaematology, this day aims to raise public awareness regarding the importance of voluntary blood donation, encourage regular non-remunerated donors, and ensure an adequate, safe blood supply across nationwide blood banks.

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111. (D) Haemopoiesis
Hemopoiesis, also termed hematopoiesis, is the physiological process responsible for the formation, development, and maturation of all cellular blood elements. Occurring primarily within the red bone marrow, multipotent hematopoietic stem cells proliferate and differentiate into mature erythrocytes, leukocytes, and platelets under the regulation of specific growth factors such as erythropoietin and thrombopoietin.

112. (C) Spleen
Senescent and damaged red blood cells are primarily filtered, engulfed, and destroyed within the spleen. Specialized splenic macrophages phagocytose aging erythrocytes as they traverse narrow endothelial slits in the cords of Billroth. Hemoglobin is broken down, recycling iron back to bone marrow for new red cell synthesis, while heme is converted into bilirubin.

113. (B) Graveyard of RBCs
The spleen is commonly referred to in human biology as the graveyard of red blood cells. As erythrocytes age over their 120-day lifespan, they lose cell membrane flexibility. The spleen's sinusoids filter out these rigid, worn-out cells, where resident macrophages phagocytose and

33. The Mid-Day Meal Scheme (PM POSHAN) primarily targets which of the following issues?
(A) Significantly reducing the overall incidence of chronic heart disease among adults
(B) Combating child malnutrition and boosting attendance
(C) Completely eradicating endemic vector-borne diseases across rural agricultural areas
(D) Providing direct financial and agricultural subsidies to smallholder farmers

34. Which initiative was launched specifically to improve nutritional outcomes for children, pregnant women, and lactating mothers across India?
(A) Swachh Bharat Abhiyan
(B) Ayushman Bharat Yojana
(C) Make in India Initiative
(D) POSHAN Abhiyaan

35. Consider the following statements about Kwashiorkor:
I. It is primarily caused by a severe deficiency of proteins in the diet.
II. It is characterized by muscle wasting combined with severe fluid retention (edema).
III. It typically occurs in infants under the age of 6 months due to lack of breast milk.
Which of the above statements is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

36. Unsafe drinking water, poor sanitation, and poor hygiene are major contributors to the spread of which disease?
(A) Dengue
(B) Malaria
(C) Cholera
(D) Tuberculosis

37. Lifestyle-related diseases, such as Type 2 diabetes and cardiovascular disease, are predominantly linked to:
(A) Sedentary habits and poor diet
(B) Bites from insect vectors and consumption of unsanitary water
(C) Specific deficiencies of single micronutrients during early childhood
(D) Acute systemic infections caused by pathogenic bacterial strains

38. The primary objective of public health policies regarding communicable diseases is to:
(A) Medical treatment of infectious diseases only after they reach severe epidemic proportions
(B) Encouraging the natural spread of viral infections to build population-wide natural immunity
(C) Implementing permanent bans on all international travel and transportation
(D) Prevent and control diseases through community measures

39. Which of the following is an effective community measure for controlling vector-borne diseases like malaria?
(A) Distributing iron and folic acid dietary supplements
(B) Spraying insecticides and removing stagnant water
(C) Providing clean purified drinking water through advanced RO filtration systems
(D) Isolating infected patients in specialized sanitized hospital wards

40. Match List I with List II:
List I: Diseases
P. Tuberculosis
Q. Cholera
R. Malaria
S. Ringworm
List II: Modes of Transmission
1. Direct skin contact / Fomites
2. Vector bite
3. Contaminated water
4. Air-borne droplets
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-2, R-3, S-1
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-3, R-2, S-4

41. Identify the incorrect statement regarding malnutrition:
(A) It encompasses both clinical undernutrition as well as states of overnutrition.
(B) It severely weakens the human immune system, making the body highly susceptible to infections.
(C) It frequently leads to permanent physical stunting and impaired cognitive development in children.
(D) It is resolved by providing more calories, regardless of quality.

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CHAPTER 19
Pathogens and Malnutrition

1. Which of the following best defines a pathogen in the context of human biology?
(A) Any microorganism that provides nutrients to the host
(B) A disease-causing microorganism or agent
(C) A chemical substance that triggers an immune response
(D) A type of white blood cell that fights infection

2. Which of the following groups contains only bacterial diseases?
(A) Dengue, Malaria, Influenza
(B) Cholera, Ringworm, Tuberculosis
(C) Typhoid, Dengue, Ringworm
(D) Tuberculosis, Cholera, Typhoid

3. Influenza and the common cold are primarily caused by which type of pathogen?
(A) Viruses
(B) Bacteria
(C) Fungi
(D) Protozoa

4. Ringworm is a common human disease characterized by dry, scaly lesions on the skin. It is caused by:
(A) A parasitic worm
(B) A bacterium
(C) A fungus
(D) A virus

5. Match List I with List II:
List I: Pathogens
P. Bacteria
Q. Virus
R. Protozoa
S. Fungi
List II: Diseases
1. Ringworm
2. Malaria
3. Typhoid
4. Dengue
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

6. Which of the following is an example of a protozoan disease in humans?
(A) Cholera
(B) Tuberculosis
(C) Dengue
(D) Malaria

7. Pathogens that cause respiratory infections like tuberculosis and influenza are most commonly transmitted through:
(A) Contaminated water
(B) Air droplets
(C) Vector insect bites
(D) Direct sexual contact

8. Which of the following statements best describes a non-communicable disease?
(A) It spreads directly from person to person through physical contact.
(B) It is caused by pathogenic agents like viruses or bacteria.
(C) It cannot be transmitted from person to person.
(D) It spreads rapidly through contaminated food and drinking water.

9. Which insect vector is primarily responsible for the transmission of the dengue virus?
(A) Female Anopheles mosquito
(B) Housefly
(C) Sandfly
(D) Aedes aegypti mosquito

10. Consider the following statements regarding Tuberculosis (TB):
I. It is caused by a viral pathogen.
II. It is primarily an air-borne disease.
III. It predominantly affects the human lungs.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

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degrade them, recycling iron while eliminating compromised erythrocytes from circulation.

114. (D) Neutrophils
Neutrophils are specialized phagocytic white blood cells that act as first responders during acute bacterial infections. Equipped with segmented nuclei and granules containing proteolytic enzymes and reactive oxygen species, neutrophils rapidly migrate from capillaries into infected tissues. They recognize, engulf, and destroy invading bacterial pathogens through phagocytosis and intracellular enzymatic degradation.

115. (A) Neutrophils
Neutrophils constitute the most abundant subpopulation of white blood cells circulating in normal human blood, accounting for approximately fifty to seventy percent of total leukocyte counts. These granular leukocytes play a critical role in innate immunity by providing rapid, effective cellular defense against acute bacterial and fungal infections through phagocytosis and antimicrobial chemical release.

116. (C) AB negative
Based on global blood group distribution patterns, AB negative is statistically identified as the rarest blood type among human populations, representing less than one percent of people worldwide. This rarity results from inheriting both the uncommon AB codominant alleles and the homozygous recessive Rh-negative genetic combination simultaneously from parental lineage.

117. (A) Both Statement I and Statement II are correct.
Voluntary blood donation drives are vital for maintaining clinical blood reserves necessary for surgical procedures, trauma care, and managing blood disorders. Because human blood possesses complex cellular structures and biochemical functions that cannot be synthetically manufactured in industrial settings, healthcare systems rely entirely on altruistic voluntary blood donations to save lives.

118. (D) O positive
Statistically, O positive is the most common blood group globally, present in approximately thirty-seven to thirty-eight percent of the world's population. This high prevalence stems from the widespread distribution of the recessive O allele combined with the high frequency of the dominant Rh-positive genetic trait across diverse ethnic and geographic populations.

119. (B) Isoimmunization
The immune response triggered in an Rh-negative mother against foreign Rh-positive red blood cells from her fetus is termed isoimmunization, or alloimmunization. This process occurs when an individual produces specific antibodies against non-self antigens derived from a genetically distinct member of the same species, leading to targeted immune responses against foreign erythrocyte surface proteins.

120. (C) Recipient Anti-A antibodies will attack and clump the donor's Group A red blood cells.
If a patient with group B blood accidentally receives group A blood, an acute immunological transfusion reaction occurs. The recipient's plasma contains naturally occurring anti-A antibodies that immediately recognize and bind to antigen A on donor erythrocytes. This antigen-antibody interaction triggers massive agglutination and complement-mediated hemolysis, causing a life-threatening hemolytic transfusion crisis.

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(A) Undernutrition
(B) Overnutrition
(C) Balanced diet
(D) Immunization

22. Which of the following is a direct consequence of severe chronic undernutrition in young children?
(A) Rapid and abnormal increase in overall body height
(B) Early-onset development of type 2 diabetes mellitus
(C) Increased biological resistance to all vector-borne diseases
(D) Stunted physical and cognitive growth

23. Overnutrition, specifically the excessive intake of calories and fats, is the leading cause of:
(A) Marasmus
(B) Obesity
(C) Kwashiorkor
(D) Goitre

24. Kwashiorkor is a form of protein-energy malnutrition primarily characterized by:
(A) Severe chronic depletion of overall body fat and skeletal muscle tissue with no fluid retention
(B) Chronically high systemic blood pressure accompanied by significantly elevated serum cholesterol
(C) Severe protein deficiency leading to abdominal edema
(D) Acute deficiency of red blood cells leading directly to severe iron-deficiency anemia

25. Select the correct sequence of the standard chain of infection for communicable diseases:
(A) Susceptible Host → Pathogen → Mode of Transmission → Portal of Exit
(B) Pathogen → Reservoir → Portal of Exit → Mode of Transmission → Portal of Entry → Susceptible Host
(C) Reservoir → Portal of Entry → Pathogen → Portal of Exit → Mode of Transmission
(D) Mode of Transmission → Portal of Entry → Pathogen → Reservoir → Susceptible Host

26. Marasmus is a severe nutritional disorder caused primarily by a simultaneous deficiency of:
(A) Proteins and total calories
(B) Iodine and Iron
(C) Vitamin A and Vitamin C
(D) Fats and water-soluble vitamins

27. Scurvy, characterized by bleeding gums and delayed wound healing, is caused by a deficiency of:
(A) Vitamin A
(B) Vitamin C
(C) Vitamin B_{12}
(D) Vitamin K

28. Which of the following essential minerals is required by the human body to synthesize the hormone thyroxine?
(A) Calcium
(B) Iodine
(C) Iron
(D) Potassium

29. Iron deficiency in the human diet is the most common cause of:
(A) Anemia
(B) Goitre
(C) Scurvy
(D) Rickets

30. Match List I with List II:
List I: Essential Nutrients
P. Iron
Q. Iodine
R. Protein only
S. Protein and Calories
List II: Deficiency Disorders
1. Goitre
2. Marasmus
3. Anemia
4. Kwashiorkor
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-2, R-1, S-3

31. A diet is considered "balanced" when it contains:
(A) Exclusively high-protein food sources required primarily to build skeletal muscle
(B) Maximum possible caloric intake required to maintain excessively high energy levels
(C) Exclusively unprocessed raw vegetables combined with purified drinking water
(D) All essential nutrients in correct proportions

32. In many developing regions, the primary socio-economic cause of widespread malnutrition is:
(A) Genetic mutations
(B) Over-availability of fast food
(C) Poverty and lack of food security
(D) Excessive use of dietary supplements

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(B) Working adult males living in industrial urban centers
(C) Elderly retired individuals living in modern urban areas
(D) Adolescents and teenagers maintaining sedentary lifestyles

54. Body Mass Index (BMI) is a simple index used to classify overweight and obesity in adults. It is calculated by:
(A) Multiplying total body weight in kilograms by total height in meters
(B) Dividing measured body weight in pounds by measured height in inches
(C) Adding total weight in kilograms to measured height in centimeters
(D) Weight in kg divided by height in meters squared

55. Match List I with List II:
List I: Insect Vectors
P. Female Anopheles mosquito
Q. Aedes mosquito
R. Housefly (Mechanical carrier)
S. Sandfly
List II: Diseases
1. Kala-azar
2. Cholera
3. Malaria
4. Dengue
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-4, S-1

56. What does the term "herd immunity" mean in the context of public health?
(A) The specific biological immunity developed naturally by domesticated livestock animals in a herd
(B) The complete and permanent structural elimination of all pathogenic microorganisms from a community
(C) Indirect protection when a large population becomes immune
(D) The widespread prophylactic use of broad-spectrum antibiotics to treat entire communities simultaneously

57. Which of the following is considered a macronutrient in a balanced diet?
(A) Iron
(B) Vitamin C
(C) Iodine
(D) Protein

58. Rickets is a condition affecting bone development in children. The primary prevention for rickets is adequate exposure to sunlight and dietary intake of:
(A) Vitamin D
(B) Vitamin C
(C) Iron
(D) Vitamin B_1

59. Which disease is characterized by an abrupt onset of high fever, severe headache, and pain behind the eyes, earning it the name "breakbone fever"?
(A) Typhoid
(B) Dengue
(C) Malaria
(D) Cholera

60. Consider the following statements regarding Malaria:
I. It is caused by a protozoan pathogen.
II. The pathogen multiplies within the red blood cells of the human host.
III. The disease is transmitted by the bite of the male Anopheles mosquito.
Which of the above statements is/are correct?
(A) I and II only
(B) I and III only
(C) II and III only
(D) I, II and III

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61. Fluorosis is a significant public health issue primarily caused by:
(A) Excess fluoride in drinking water
(B) A chronic lack of essential fluoride additives in commercial table salt
(C) Severe industrial air pollution released continuously from local factories
(D) Frequent bites from disease-carrying mosquitoes in desert regions

62. Which of the following represents 'hidden hunger'?
(A) The psychological sensation of feeling hungry immediately after consuming a very large meal
(B) A temporary medical condition where the human stomach becomes physically empty between meals
(C) Deficiency of micronutrients despite adequate caloric intake
(D) Severe long-term protein-energy malnutrition

42. Which diagnostic test is widely used to confirm a suspected case of Typhoid fever?
(A) Widal test
(B) ELISA test
(C) Mantoux test
(D) PCR test

43. Plasmodium falciparum, the pathogen that causes the most severe and fatal form of malaria, is a:
(A) Bacterium
(B) Protozoan
(C) Virus
(D) Fungus

44. What is the role of white blood cells (leukocytes) during a pathogen infection?
(A) They transport vital oxygen and metabolic nutrients to affected body tissues.
(B) They recognize and destroy invading pathogens.
(C) They initiate and facilitate the enzymatic clotting of blood over open wounds.
(D) They secrete chemical toxins that actively assist invading pathogens to multiply.

45. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Active immunity tends to be long-lasting or permanent.
Reason (R): Active immunity involves the production of memory cells by the host's own immune system in response to an antigen.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

46. The BCG vaccine is administered primarily to provide immunity against which disease?
(A) Cholera
(B) Dengue
(C) Tuberculosis (TB)
(D) Typhoid

47. Which of the following habits contributes significantly to the problem of antibiotic resistance?
(A) Completing the full course of prescribed antibiotics
(B) Using antibiotics strictly under a doctor's guidance
(C) Using antibiotics only for confirmed bacterial infections
(D) Stopping antibiotic intake as soon as symptoms disappear

48. Oral Rehydration Solution (ORS) is a highly effective, low-cost community intervention used to prevent death from dehydration caused by:
(A) Severe strains of vector-borne malaria
(B) Pulmonary and extrapulmonary tuberculosis
(C) Cholera and diarrhea
(D) Seasonal viral influenza infections

49. Which of the following is considered an air-borne pathogen?
(A) Salmonella typhi
(B) Mycobacterium tuberculosis
(C) Plasmodium vivax
(D) Vibrio cholerae

50. Consider the following processes involved in municipal water treatment:
I. Filtration
II. Chlorination (Disinfection)
III. Sedimentation
IV. Coagulation
Which of the following represents the correct sequential order of these processes to ensure water is safe from pathogens?
(A) IV, III, I, II
(B) III, IV, II, I
(C) I, III, IV, II
(D) IV, I, III, II

51. The primary structural component that is inhibited by the antibiotic penicillin in bacterial cells is the:
(A) Cell wall
(B) Cell membrane
(C) Nucleus
(D) Ribosome

52. Which disease vector requires clean, stagnant water to lay its eggs and is largely responsible for urban dengue outbreaks?
(A) Housefly
(B) Female Anopheles mosquito
(C) Aedes aegypti mosquito
(D) Sandfly

53. Which of the following groups is most vulnerable to the severe impacts of malnutrition and related infectious diseases?
(A) Young children and pregnant women

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74. Which of the following is NOT an example of a fungal disease?
(A) Influenza
(B) Athlete's foot
(C) Ringworm
(D) Candidiasis

75. Match List I with List II:
List I: Pathogens
P. Mycobacterium tuberculosis
Q. Vibrio cholerae
R. Salmonella typhi
S. Plasmodium falciparum
List II: Diseases
1. Cholera
2. Malaria
3. Typhoid
4. Tuberculosis (TB)
(A) P-1, Q-4, R-2, S-3
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

76. Anthelmintic drugs are commonly administered in public health programs to treat infections caused by:
(A) Fungi
(B) Parasitic worms
(C) Viruses
(D) Bacteria

77. Which of the following interventions is the most effective long-term community measure to eradicate diseases like cholera and typhoid?
(A) Providing safe water and sanitation infrastructure
(B) Frequent application of topical antiseptic skin ointments across communities
(C) Widespread distribution and daily usage of insecticide-treated mosquito nets
(D) Direct implementation of a high-protein dietary policy for all households

78. In the context of nutrition, what does the term 'stunting' refer to?
(A) Being significantly overweight relative to standard measurements for one's age
(B) Having an unusually high skeletal bone mass and elevated overall bone density
(C) Low height for a child's age due to poor growth
(D) Experiencing a rapid and sudden increase in physical height during early puberty

79. Which of the following is an incorrect statement about communicable diseases?
(A) They can be easily transferred from an infected animal reservoir to a susceptible human host.
(B) They are primarily caused by microscopic pathogenic microorganisms such as bacteria or viruses.
(C) They can be effectively controlled by widespread public health measures such as vaccination.
(D) They are purely genetic and cannot spread via air.

80. Select the correct sequence of the stages of the Plasmodium life cycle after an infected mosquito bites a human host:
(A) Sporozoites enter blood → Multiplication in liver → Infection of red blood cells → Gametocyte formation
(B) Infection of red blood cells → Multiplication in liver → Sporozoites enter blood → Gametocyte formation
(C) Gametocyte formation → Multiplication in liver → Sporozoites enter blood → Infection of red blood cells
(D) Multiplication in liver → Sporozoites enter blood → Gametocyte formation → Infection of red blood cells

81. Which vitamin is also chemically known as Retinol?
(A) Vitamin C
(B) Vitamin A
(C) Vitamin D
(D) Vitamin K

NODIA

82. Which of the following diseases is successfully prevented by avoiding direct contact with infected persons and maintaining personal hygiene by not sharing towels or clothes?
(A) Malaria
(B) Dengue
(C) Goitre
(D) Ringworm

83. The problem of malnutrition is heavily influenced by socio-economic factors. Which of the following is the most significant root cause?
(A) Poverty and lack of food purchasing power
(B) High levels of rigorous daily physical exercise among the rural population
(C) Widespread over-reliance on commercial multivitamin dietary supplements

leading directly to progressive skeletal muscle wasting

63. Proper disposal of household wastewater and covering open drains in a community primarily help in reducing the incidence of:
(A) Highly contagious air-borne respiratory diseases like Tuberculosis
(B) Chronic nutritional deficiency disorders like Scurvy and Rickets
(C) Non-communicable metabolic lifestyle diseases like Obesity
(D) Vector-borne diseases

64. A child presents with severely wasted muscles, thin limbs, and a prominent rib cage. There is no fluid retention (edema) in the body. The child is most likely suffering from:
(A) Kwashiorkor
(B) Obesity
(C) Marasmus
(D) Goitre

65. The immune protection acquired by an infant through the mother's milk (colostrum) is an example of:
(A) Artificial active immunity
(B) Natural passive immunity
(C) Natural active immunity
(D) Artificial passive immunity

66. Night blindness is largely preventable by ensuring adequate consumption of which of the following foods?
(A) Heavily processed and polished white rice grains
(B) Refined white wheat flour and processed industrial sugar
(C) Commercially produced carbonated sweetened beverages
(D) Carrots and leafy green vegetables

67. Which of the following terms refers specifically to a disease that affects a large number of people across multiple countries or continents simultaneously?
(A) Pandemic
(B) Endemic
(C) Epidemic
(D) Sporadic

68. Which pathogen is correctly paired with the disease it causes?
(A) Vibrio cholerae – Typhoid
(B) Mycobacterium tuberculosis – Dengue
(C) Plasmodium vivax – Malaria
(D) Salmonella typhi – Cholera

69. The main principle of disease control in public health policy emphasizes:
(A) Prevention over cure
(B) Cure over prevention
(C) Reliance solely on natural immunity
(D) Eradicating human populations in infected zones

70. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Proper hygiene and sanitation are ineffective against the spread of typhoid.
Reason (R): Typhoid is transmitted primarily by the bite of an infected mosquito.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Both Assertion (A) and Reason (R) are false.

71. Excessive consumption of junk food, which is high in sugars and unhealthy fats but low in essential nutrients, most directly contributes to:
(A) Pulmonary tuberculosis infections
(B) Obesity and lifestyle diseases
(C) Acute bacterial cholera outbreaks
(D) Severe protein-energy malnutrition disorders

72. Which of the following best describes the function of antibodies in the human body?
(A) Specialized digestive enzymes that break down complex sugars and starches in the stomach
(B) Essential dietary vitamins required continuously for healthy bone development and growth
(C) Proteins that recognize and neutralize foreign pathogens.
(D) Microscopic pathogenic agents that cause mild, temporary, and harmless systemic infections

73. Which mineral is crucial for the formation of hemoglobin in red blood cells?
(A) Calcium
(B) Sodium
(C) Iodine
(D) Iron

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11. Cholera outbreaks are most commonly associated with which mode of transmission?
(A) Inhalation of airborne dust particles
(B) Contaminated water and food
(C) Direct physical skin-to-skin contact
(D) Direct bite from an infected mosquito vector

12. The pathogen responsible for typhoid fever, Salmonella typhi, primarily targets which part of the human body?
(A) Central nervous system
(B) Intestines
(C) Respiratory tract
(D) Cardiovascular system

13. Which of the following organs acts as the primary mechanical barrier in the human immune system to prevent the entry of pathogens?
(A) Skin
(B) Spleen
(C) Liver
(D) Intestine

14. What is the fundamental principle behind immunization or vaccination?
(A) Administering powerful antibiotics into the bloodstream to kill all future pathogens
(B) Destroying all red blood cells temporarily to prevent rapid pathogen multiplication
(C) Inducing immune memory using a weakened pathogen
(D) Providing lifelong passive immunity through regular injections of synthetic chemicals

15. Match List I with List II:
List I: Vitamins
P. Vitamin A
Q. Vitamin B_1
R. Vitamin C
S. Vitamin D
List II: Deficiency Diseases
1. Scurvy
2. Rickets
3. Night Blindness
4. Beriberi
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-1, R-4, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-4, R-1, S-2

16. Antibiotics are medicinal compounds generally prescribed to treat infections caused by:
(A) Viruses
(B) Fungi
(C) Bacteria
(D) Protozoa

17. Which of the following best defines the medical problem of antibiotic resistance?
(A) When the human digestive system permanently stops absorbing oral antibiotic drugs
(B) When bacteria develop the ability to survive antibiotics
(C) When individual patients develop severe allergic reactions to antibiotic medications
(D) When pathogenic viruses rapidly become completely immune to standard anti-viral drugs

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18. Maintaining short and clean fingernails, bathing daily, and washing hands before meals are examples of:
(A) Public health policy
(B) Community sanitation
(C) Immunization practices
(D) Personal hygiene

19. Community sanitation aims to prevent disease outbreaks primarily by:
(A) Safe waste disposal and maintaining clean public environments
(B) Providing free broad-spectrum antibiotics to all citizens in the community
(C) Encouraging daily physical exercise, yoga, and healthy dietary habits
(D) Banning the commercial sale and consumption of processed fast food

20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Antibiotics like penicillin are widely used to cure the common cold.
Reason (R): The common cold is caused by rhinoviruses, and antibiotics inhibit viral cell wall synthesis.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Both Assertion (A) and Reason (R) are false.

21. Which term describes a state where an individual's diet lacks the required amount of essential nutrients, leading to impaired health?

(D) Consistent and strict adherence to a traditional balanced dietary routine

84. Which biological defense mechanism is commonly known as the "first line of defense" against pathogen entry?
(A) Specific circulating antibodies present in the blood serum
(B) Specialized white blood cells circulating throughout the body
(C) Skin and mucous membranes
(D) Broad-spectrum prescription antibiotics

85. Consider the following statements about Dengue fever:
I. It is a viral disease.
II. It is characterized by high fever and severe joint and muscle pain.
III. A severe decrease in blood platelet count is a major clinical sign.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

86. Which chemical is most commonly and economically used to disinfect municipal water supplies to prevent water-borne diseases?
(A) Sodium chloride
(B) Potassium permanganate
(C) Fluorine
(D) Chlorine

87. Beriberi is a disease resulting from a deficiency of:
(A) Ascorbic acid (Vitamin C)
(B) Thiamine (Vitamin B_1)
(C) Calciferol (Vitamin D)
(D) Retinol (Vitamin A)

88. Which of the following dietary items is the best natural source of Vitamin C?
(A) Whole cow's milk
(B) Processed red meat
(C) Citrus fruits
(D) Polished white rice grains

89. The term 'pathogenicity' refers to:
(A) The biochemical process of synthesizing commercial antibiotic compounds
(B) The enzymatic process of digesting complex proteins in the human stomach
(C) The innate physiological resistance of a host organism to infectious disease
(D) Ability of a microorganism to cause disease

90. Match List I with List II:
List I: Types of Immunity
P. Active Natural Immunity
Q. Active Artificial Immunity
R. Passive Natural Immunity
S. Passive Artificial Immunity
List II: Mechanisms
1. Injection of pre-formed antibodies (antiserum)
2. Transfer of antibodies through mother's milk (colostrum)
3. Recovery from a natural clinical infection
4. Administration of a vaccine
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-2, R-3, S-4

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91. A public health policy that focuses on eliminating the breeding grounds of the Aedes aegypti mosquito is attempting to control which disease?
(A) Malaria
(B) Dengue
(C) Cholera
(D) Typhoid

92. Identify the odd one out from the following list based on the nature of the disease:
(A) Diabetes
(B) Tuberculosis
(C) Obesity
(D) Hypertension

93. The DPT vaccine administered to infants provides protection against:
(A) Diphtheria, Pertussis, Tetanus
(B) Acute viral Dengue, Polio, and Typhoid fever
(C) Bacterial Dysentery, Pneumonia, and Tuberculosis
(D) Chronic Dermatitis, Paratyphoid, and Typhus fever

94. What is the primary function of memory B-cells and T-cells in the immune system?
(A) To physically trap circulating pathogens like a cellular fibrous web
(B) To transport essential dissolved oxygen directly to primary immune organs
(C) To mount a rapid immune response upon re-exposure
(D) To synthesize and secrete broad-spectrum

like tuberculosis.

115. Fungal infections like ringworm are opportunistic and spread most easily in environments that are:
(A) Warm and moist
(B) Extremely cold and dry
(C) Highly sanitized and sterile
(D) High in ultraviolet radiation

116. Which specific nutrient deficiency impairs cognitive development, learning ability, and IQ levels in young children?
(A) Vitamin C
(B) Calcium
(C) Iodine
(D) Vitamin K

117. Which of the following diseases can be completely prevented by an effective and widely available vaccination administered during childhood?
(A) Polio
(B) Malaria
(C) Dengue
(D) Ringworm

118. In terms of public health, why are non-communicable diseases (NCDs) becoming an increasing problem in modern society?
(A) Due to the rapid and uncontrollable genetic mutation of newly emerging viral strains
(B) Due to the widespread clinical failure and resistance of standard antibiotic treatments
(C) Due to a massive unmitigated increase in disease-carrying vector mosquito populations
(D) Due to unhealthy diets, physical inactivity, and tobacco use

119. A pregnant woman who lacks sufficient folic acid in her diet is at a higher risk of:
(A) Contracting severe vector-borne malaria infections during pregnancy
(B) Having a child with neural tube defects
(C) Developing severe night blindness and vitamin A deficiency
(D) Rapidly spreading communicable viral diseases to family members

120. The most widely accepted public health definition of malnutrition is:
(A) Consuming excessive amounts of dietary sugar, saturated fats, and processed carbohydrates daily
(B) A rare genetic condition inherited directly from biological parents that causes rapid weight loss
(C) Imbalance between nutrients needed by the body and nutrients received
(D) An acute allergic reaction triggered in the digestive system by specific foreign food proteins

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lifestyle, while non-communicable diseases are caused by viruses.
(C) Communicable diseases are infectious and can spread, while non-communicable diseases cannot.
(D) Non-communicable diseases can be cured by antibiotics.

105. Match List I with List II:
List I: Programs / Terms
P. POSHAN Abhiyaan
Q. Mid-Day Meal Scheme
R. Swachh Bharat Mission
S. Universal Immunization Programme
List II: Primary Objectives
1. Improving community sanitation and ending open defecation
2. Preventing vaccine-preventable diseases in children
3. Reducing nutritional stunting, undernutrition, and anemia
4. Improving nutritional status and attendance of school children
(A) P-4, Q-3, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-3, Q-4, R-1, S-2

106. Which of the following macronutrients provides the highest amount of energy per gram?
(A) Fats
(B) Carbohydrates
(C) Proteins
(D) Water

107. Excessive use of chemical fertilizers and poor sanitation can lead to groundwater contamination with nitrates, causing which condition in infants when the water is consumed?
(A) Severe Vitamin C deficiency (Scurvy)
(B) Blue baby syndrome
(C) Vitamin A deficiency (Night blindness)
(D) Bone weakening disease (Rickets)

108. The pathogen Vibrio cholerae is best described anatomically as a:
(A) Highly coiled spiral-shaped virus
(B) Comma-shaped bacterium
(C) Microscopic spherical fungus
(D) Elongated rod-shaped protozoan

109. Which among the following is NOT an essential component of a balanced diet?
(A) Synthetic food coloring
(B) Roughage (Dietary fiber)
(C) Vitamins and minerals
(D) Carbohydrates

110. Consider the following statements concerning antibiotic resistance:
I. It occurs when pathogens undergo changes to survive the drugs designed to kill them.
II. It is accelerated by the misuse and overuse of antibiotics in humans and agriculture.
III. It makes standard medical treatments less effective and increases the risk of severe illness.
Which of the above statements is/are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

111. During a typhoid infection, a patient is typically advised to consume boiled water and well-cooked food to prevent:
(A) Disease-carrying insect vectors from biting them repeatedly during recovery
(B) The rapid evolutionary development of multi-drug antibiotic resistance
(C) The indirect airborne transmission and spread of the pathogenic disease
(D) Further ingestion of bacteria from contaminated sources

NODIA

112. The vector responsible for transmitting the malaria parasite belongs to the genus:
(A) Culex
(B) Aedes
(C) Anopheles
(D) Phlebotomus

113. An infectious disease that is transmitted through the bite of an infected animal, such as a dog, is:
(A) Cholera
(B) Rabies
(C) Tuberculosis
(D) Typhoid

114. Why is indiscriminate spitting in public places considered a significant public health hazard?
(A) It drastically alters the surrounding micro-climate and regional ambient temperature
(B) It significantly promotes the rapid breeding of disease-carrying Aedes mosquitoes
(C) It causes a direct and immediate widespread surge in severe water-borne diseases
(D) It spreads airborne respiratory pathogens

transfers the viral pathogen directly into the host's bloodstream.

10. (B) II and III only
Tuberculosis is an infectious disease caused by the bacterium Mycobacterium tuberculosis, making the claim of a viral origin incorrect. It is transmitted primarily through infectious airborne droplets released when an infected individual coughs or sneezes. Once inhaled, the bacteria predominantly attack human lung tissue, establishing pulmonary tuberculosis, though extrapulmonary forms can also occur.

11. (B) Contaminated water and food
Cholera is an acute diarrheal infection caused by ingesting food or water contaminated with the bacterium Vibrio cholerae. In environments with inadequate sanitation, municipal water supplies or food sources become contaminated with human fecal material containing the pathogen. Ingestion leads to severe watery diarrhea, rapid fluid loss, and life-threatening dehydration if left untreated.

12. (B) Intestines
Salmonella typhi, the bacterial pathogen responsible for typhoid fever, primarily infects the human gastrointestinal tract. After entering the body through contaminated food or water, the bacteria multiply within the small intestine. They penetrate the intestinal mucosal lining, cause ulceration and systemic fever, and can spread into the bloodstream and liver if untreated.

13. (A) Skin
The skin serves as the primary continuous mechanical and physical barrier of the innate immune system. Its tough keratinized outer layer physically prevents pathogenic bacteria, viruses, and fungi from penetrating bodily tissues. Furthermore, skin secretions containing antimicrobial peptides and organic acids create an inhospitable, acidic surface environment that actively inhibits microbial colonisation and growth.

14. (C) Inducing immune memory using a weakened pathogen
Vaccination operates on the principle of immunological memory. Introducing a weakened, inactivated, or antigenic component of a pathogen stimulates primary immune responses without causing full-scale disease. Memory B and T cells are generated, enabling the host immune system to recognize and rapidly destroy the actual pathogen if exposed in the future, providing long-term immunity.

15. (D) P-3, Q-4, R-1, S-2
Vitamin A deficiency causes night blindness due to impaired rhodopsin synthesis. Vitamin B_1 deficiency causes beriberi, affecting nervous and cardiovascular function. Vitamin C deficiency results in scurvy, characterized by connective tissue degradation and bleeding gums. Vitamin D deficiency leads to rickets, causing defective bone mineralization in growing children. Matching these pairs correctly yields the sequence P-3, Q-4, R-1, and S-2.

16. (C) Bacteria
Antibiotics are pharmaceutical agents specifically designed to treat bacterial infections. They work by selectively disrupting biochemical mechanisms unique to prokaryotic bacterial cells, such as cell wall synthesis, protein translation, or bacterial DNA replication. Antibiotics are entirely ineffective against viral infections like flu, as well as fungal and protozoan pathogens, which require distinct targeted therapies.

17. (B) When bacteria develop the ability to survive antibiotics
Antibiotic resistance occurs when bacteria adapt and develop mechanisms to survive exposures to antimicrobial drugs designed to kill them or inhibit their growth. Through genetic mutations or horizontal gene transfer, resistant bacterial strains continue multiplying despite standard antibiotic treatment. This makes clinical infections persistent, harder to cure, and a major threat to global public health.

18. (D) Personal hygiene
Personal hygiene involves individual practices and habits maintained to preserve physical cleanliness and personal health. Actions such as washing hands with soap before eating, keeping fingernails clean and trimmed, and bathing daily directly reduce the microbial load on the skin. These self-directed routines prevent the transfer and ingestion of disease-causing pathogens into the body.

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ANSWERS

1. (B) A disease-causing microorganism or agent
In human biology, a pathogen is any microscopic organism or infectious agent capable of producing disease within a host. These biological agents include bacteria, viruses, fungi, protozoa, and parasitic worms. Pathogens invade host tissues, multiply rapidly, release harmful toxic substances, and disrupt normal physiological operations, ultimately leading to various infectious illnesses and clinical health conditions.

2. (D) Tuberculosis, Cholera, Typhoid
Tuberculosis, cholera, and typhoid are all bacterial diseases caused by specific prokaryotic pathogens. Mycobacterium tuberculosis causes pulmonary tuberculosis, Vibrio cholerae leads to severe cholera through contaminated water, and Salmonella typhi causes typhoid fever. In contrast, dengue and influenza are viral infections, malaria is caused by protozoa, and ringworm is a fungal infection affecting human skin tissues.

3. (A) Viruses
Influenza and the common cold are infectious respiratory illnesses caused primarily by viral pathogens. The common cold is predominantly triggered by rhinoviruses, whereas influenza is caused by influenza viruses. These viral particles infect the epithelial cells of the upper respiratory tract, multiplying inside host cells and inducing symptoms like fever, cough, sore throat, and general body fatigue.

4. (C) A fungus
Ringworm, also known scientifically as tinea, is a contagious fungal infection of the skin, nails, or scalp. It is caused by dermatophytes, which are specialized fungi that feed on keratin protein present in dead skin layers. The condition produces characteristic red, itchy, dry, and scaly circular lesions with clearer centers across the affected body skin areas.

5. (A) P-3, Q-4, R-2, S-1
Bacteria cause typhoid fever through Salmonella typhi infection. Viruses are responsible for dengue, transmitted via Aedes mosquito vectors. Protozoa cause malaria through Plasmodium species carried by Anopheles mosquitoes. Fungi cause ringworm infections affecting human epidermal tissues. Correctly pairing each pathogen with its respective disease confirms that bacteria match typhoid, viruses match dengue, protozoa match malaria, and fungi match ringworm.

6. (D) Malaria
Malaria is a human disease caused by unicellular protozoan parasites belonging to the genus Plasmodium. The parasite enters the human bloodstream through the bite of an infected female Anopheles mosquito. In contrast, cholera and tuberculosis are bacterial infections, whereas dengue is a viral illness caused by the dengue virus and transmitted by Aedes mosquito vectors.

NODIA

7. (B) Air droplets
Respiratory pathogens causing diseases like tuberculosis and influenza spread predominantly through airborne droplets emitted when infected individuals cough, sneeze, speak, or exhale. These microscopic respiratory droplets contain active pathogens that remain suspended in the air or travel short distances, infecting susceptible individuals who inhale them into their lungs or upper respiratory tracts.

8. (C) It cannot be transmitted from person to person.
Non-communicable diseases are medical conditions that are not caused by infectious agents and cannot spread directly or indirectly from one individual to another. These chronic conditions generally develop over long periods due to genetic predispositions, environmental factors, physiological aging, or personal lifestyle choices, including poor dietary habits, physical inactivity, and tobacco consumption.

9. (D) Aedes aegypti mosquito
The Aedes aegypti mosquito is the principal biological vector responsible for transmitting the dengue virus to humans. This mosquito species bites primarily during daytime hours and thrives in urban environments where clean, artificial container water accumulates. When an infected mosquito feeds on human blood, it

community dissemination of resistant bacterial strains that fail standard therapies.

48. (C) Cholera and diarrhea
Oral Rehydration Solution, consisting of a balanced mixture of clean water, glucose, and essential salts, is a key clinical intervention for managing acute diarrheal illnesses like cholera. Acute diarrhea causes rapid bodily loss of water and essential electrolytes, leading to severe dehydration and circulatory collapse. Administration of ORS restores hydration balance and reduces mortality.

49. (B) Mycobacterium tuberculosis
Mycobacterium tuberculosis is an airborne bacterial pathogen that causes pulmonary tuberculosis. When an infected individual with active disease coughs, sneezes, or talks, microscopic droplet nuclei containing viable bacteria are expelled into the surrounding air. These infectious particles remain suspended in ambient air currents and can be inhaled into the lungs of susceptible individuals.

50. (A) IV, III, I, II
Municipal water treatment follows a structured sequential process to eliminate impurities and microbial pathogens. Coagulation is performed first by adding chemical coagulants to form flocs, followed by sedimentation, where heavy flocs settle out. Filtration then removes fine suspended particles, and final chlorination disinfected the water by destroying pathogenic bacteria and viruses.

51. (A) Cell wall
Penicillin is a beta-lactam antibiotic that targets bacterial cell wall synthesis. It inhibits transpeptidase enzymes responsible for cross-linking peptidoglycan polymers, which form the rigid outer cell wall of bacteria. Without a structurally intact cell wall, internal osmotic pressure causes the bacterial cell to lyse and die, rendering the drug bactericidal.

52. (C) Aedes aegypti mosquito
The Aedes aegypti mosquito vector breeds in clean, stagnant water contained in artificial domestic receptacles such as storage tanks, discarded tyres, pots, and flower buckets in urban settings. Female Aedes mosquitoes transmit dengue virus during daytime blood feeds. Managing and removing artificial open water collections breaks their breeding cycle and reduces urban outbreaks.

53. (A) Young children and pregnant women
Young children and pregnant women are physiologically most vulnerable to the adverse effects of malnutrition and infectious diseases. Young children possess rapidly developing tissues and immature immune systems, whereas pregnant women experience increased metabolic demands to support fetal development. Nutritional deficits in these groups impair immune defenses, elevating mortality risks from infectious pathogens.

54. (D) Weight in kg divided by height in meters squared
Body Mass Index is an anthropometric measurement used to assess body mass relative to height in adult populations. It is mathematically calculated by taking total body weight in kilograms and dividing it by the square of height in meters. BMI values classify individuals into categories including underweight, normal, overweight, and obese.

55. (B) P-3, Q-4, R-2, S-1
Female Anopheles mosquitoes serve as vectors for malaria. Aedes mosquitoes transmit dengue virus during daytime feeds. Houseflies act as mechanical carriers transporting pathogens like Vibrio cholerae to uncontained food. Sandflies are biological vectors transmitting Leishmania parasites, which cause Kala-azar. The correct pairing sequence between insect vectors and their respective vector-borne diseases is P-3, Q-4, R-2, S-1.

56. (C) Indirect protection when a large population becomes immune
Herd immunity refers to the indirect protection from infectious diseases conferred upon unvaccinated or vulnerable individuals when a significant proportion of the population develops immunity through prior infection or vaccination. High population-wide immune coverage reduces active pathogen transmission, decreasing the likelihood that unimmunized individuals will encounter the infectious disease agent.

57. (D) Protein
Macronutrients are organic dietary nutrients required by the human body in relatively large gram quantities to supply energy and

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19. (A) Safe waste disposal and maintaining clean public environments
Community sanitation focuses on broad public health measures designed to maintain clean shared living environments. This includes proper liquid and solid waste management, safe sewage treatment, vector breeding control, and ensuring clean public water systems. Eliminating environmental contamination prevents vector reproduction and breaks transmission pathways of infectious agents, reducing community-wide disease transmission.

20. (D) Both Assertion (A) and Reason (R) are false.
Both statements are false. Penicillin and other antibiotics target bacterial cell wall synthesis and are completely ineffective against viral infections such as the common cold. The common cold is caused by viruses, predominantly rhinoviruses, which lack bacterial cell wall structures entirely. Treating viral colds with antibiotics is medically ineffective and contributes directly to antibiotic resistance.

21. (A) Undernutrition
Undernutrition is a form of malnutrition that occurs when an individual's intake of food energy or essential nutrients is insufficient to satisfy basic physiological growth and metabolic demands. It leads to severe weight loss, micronutrient deficiencies, stunted growth, and immune system impairment, leaving the body vulnerable to opportunistic bacterial and viral infections.

22. (D) Stunted physical and cognitive growth
Chronic undernutrition during early childhood severely restricts physiological development due to insufficient energy, protein, and essential micronutrients. This nutritional deficit impairs cellular growth and brain tissue development, resulting in permanent stunting, where a child is significantly shorter than normal for their age, along with irreversible long-term deficits in cognitive and intellectual capacity.

23. (B) Obesity
Overnutrition is a form of malnutrition resulting from the excessive intake of nutrients, particularly high-calorie fats and refined carbohydrates, exceeding physiological body requirements. This continuous positive energy balance leads to abnormal or excessive fat accumulation in adipose tissues, resulting directly in obesity and increasing the risk of chronic metabolic disorders.

24. (C) Severe protein deficiency leading to abdominal edema
Kwashiorkor is a form of severe protein-energy malnutrition occurring when dietary protein is inadequate despite sufficient total caloric intake. Low blood plasma protein levels cause fluid to leak from blood vessels into interstitial tissue spaces. Clinical signs include peripheral edema, a distended abdominal belly, thin limbs, skin lesions, and hair color changes.

25. (B) Pathogen → Reservoir → Portal of Exit → Mode of Transmission → Portal of Entry → Susceptible Host
The standard chain of infection models how communicable diseases spread. The pathogen originates within a reservoir, exits via a portal of exit, travels through a specific mode of transmission, enters a new host through a portal of entry, and infects a susceptible host lacking adequate immunity. Interrupting any step breaks disease transmission.

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26. (A) Proteins and total calories
Marasmus is a severe form of protein-energy malnutrition caused by a deficiency in both dietary proteins and total daily calories. It typically affects infants under one year old, leading to severe body tissue wasting, complete loss of subcutaneous fat, muscle loss, prominent skeletal bones, and extreme growth retardation without peripheral fluid retention.

27. (B) Vitamin C
Scurvy is a nutritional deficiency disease caused by a lack of Vitamin C, also known as ascorbic acid, in the human diet. Vitamin C is essential for synthesizing collagen, a vital structural protein. Its deficiency leads to fragile blood vessels, subcutaneous hemorrhages, swollen bleeding gums, joint pain, and delayed wound healing.

28. (B) Iodine
Iodine is an essential trace element required by the thyroid gland to synthesize thyroid hormones, including thyroxine and triiodothyronine. These metabolic hormones regulate basal energy expenditure, body growth, and neurological development. Chronic dietary iodine deficiency prevents sufficient hormone synthesis, causing

thyroid gland hypertrophy, commonly known as goitre, and cognitive development impairment.

29. (A) Anemia
Iron is a critical micronutrient required for the synthesis of hemoglobin, the iron-rich protein in red blood cells that binds and transports oxygen throughout human tissues. Inadequate dietary iron leads to iron-deficiency anemia, characterized by reduced hemoglobin levels, pale skin, chronic fatigue, shortness of breath, and decreased overall work capacity.

30. (C) P-3, Q-1, R-4, S-2
Iron deficiency causes anemia due to decreased hemoglobin production. Iodine deficiency causes goitre through thyroid gland enlargement. Protein-only deficiency results in kwashiorkor, presenting with fluid retention edema. Simultaneous deficiency of protein and calories causes marasmus, resulting in severe tissue wasting. The correct matching sequence is therefore P-3, Q-1, R-4, and S-2.

31. (D) All essential nutrients in correct proportions
A balanced diet is defined as a diet that provides all essential macronutrients, including carbohydrates, proteins, and fats, alongside necessary micronutrients like vitamins and minerals, dietary fiber, and water. These nutrients must be present in appropriate, scientifically recommended proportions to meet daily metabolic demands and maintain overall human physiological health.

32. (C) Poverty and lack of food security
Poverty and household food insecurity represent the primary root socio-economic drivers of widespread undernutrition in developing areas. Low family income directly restricts access to nutritious, high-quality food, leading to chronic dietary deficits. Unfavorable economic conditions impair dietary diversity, increasing susceptibility to severe protein-energy malnutrition and micronutrient deficiencies across vulnerable populations.

33. (B) Combating child malnutrition and boosting attendance
The Mid-Day Meal Scheme, rebranded as PM POSHAN, provides free cooked nutritional lunches to primary and upper primary school children across public schools in India. This flagship public welfare program addresses two primary goals: improving the nutritional status of school-aged children to prevent undernutrition and encouraging daily school enrollment and attendance.

34. (D) POSHAN Abhiyaan
POSHAN Abhiyaan, also known as the National Nutrition Mission, is India's flagship public health initiative launched to improve nutritional outcomes for young children, pregnant women, and lactating mothers. The scheme uses technology, inter-ministerial convergence, and behavioral change campaigns to systematically reduce stunting, undernutrition, anemia, and low birth weight across the nation.

35. (A) I and II only
Kwashiorkor is caused by severe dietary protein deficiency despite adequate caloric intake, leading to characteristic muscle wasting accompanied by fluid retention and edema. It typically affects older infants and toddlers between one and three years of age during weaning, making the claim regarding infants under six months incorrect, as they are protected by breastfeeding.

36. (C) Cholera
Cholera is a water-borne bacterial infection transmitted via the fecal-oral route through unsanitary drinking water and poor food hygiene. Consuming water contaminated with Vibrio cholerae causes severe diarrhea and vomiting. Inadequate sanitation infrastructure and poor personal hygiene habits greatly facilitate the rapid community transmission and outbreak of this acute diarrheal disease.

37. (A) Sedentary habits and poor diet
Non-communicable lifestyle diseases, including type 2 diabetes, hypertension, and cardiovascular disorders, develop primarily due to modifiable behavioral risk factors. Lack of regular physical activity, combined with diets high in energy-dense, processed foods, refined sugars, and saturated fats, alters metabolic pathways. Over time, these daily habits lead to systemic metabolic dysfunctions.

38. (D) Prevent and control diseases through community measures
The overarching goal of public health policy regarding communicable diseases is population-level disease prevention and health promotion. Rather than focusing solely on individual clinical

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treatment, public health strategies emphasize primary prevention through community sanitation, clean water access, mass vaccination programs, vector control, health education, and disease surveillance to block transmission pathways.

39. (B) Spraying insecticides and removing stagnant water
Effective control of vector-borne diseases like malaria relies on interrupting the biological lifecycle of mosquito vectors. Environmental management strategies, such as eliminating stagnant standing water where Anopheles mosquitoes lay eggs, combined with target spraying of insecticides and utilizing larvicides, significantly reduce local mosquito populations and reduce infection transmission rates in communities.

40. (C) P-4, Q-3, R-2, S-1
Tuberculosis spreads via airborne droplets from infected coughs. Cholera spreads through water contaminated with Vibrio cholerae. Malaria is transmitted via vector bites from infected female Anopheles mosquitoes. Ringworm spreads through direct skin contact or infected fomites. The correct structural matching between diseases and their respective transmission routes yields P-4, Q-3, R-2, and S-1.

41. (D) It is resolved by providing more calories, regardless of quality.
Malnutrition cannot be resolved by simply increasing total caloric quantity without considering dietary quality. Malnutrition encompasses both undernutrition and overnutrition, including micronutrient deficiencies. Consuming empty calories lacking essential proteins, vitamins, and minerals fails to correct nutrient deficiencies, impairs immune response, and can exacerbate overall obesity and chronic metabolic health complications.

42. (A) Widal test
The Widal test is a serological diagnostic method widely used to detect typhoid fever. It measures agglutinating antibody titers against the O and H somatic antigens of Salmonella typhi in a patient's serum. A significant rise in specific antibody titers supports the clinical confirmation of active human enteric typhoid infection.

43. (B) Protozoan
Plasmodium falciparum is a unicellular eukaryotic protozoan parasite transmitted to humans through the bite of infected female Anopheles mosquitoes. It causes falciparum malaria, the most severe and potentially fatal form of malaria, characterized by rapid destruction of red blood cells, microvascular obstruction, severe anemia, and high periodic fever spikes in patients.

44. (B) They recognize and destroy invading pathogens.
White blood cells, or leukocytes, constitute the primary cellular defense of the human immune system. During an infection, various specialized types of leukocytes, such as neutrophils, macrophages, and lymphocytes, identify, engulf, and destroy invading viral, bacterial, fungal, or protozoan pathogens through phagocytosis, specific antibody secretion, and direct targeted cellular destruction.

45. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Active immunity provides durable, long-lasting protection because the host's own immune system encounters an antigen and mounts an active immune response. This process generates long-lived memory B and T cells capable of recognizing the specific pathogen upon re-exposure, allowing for a rapid, targeted response that effectively prevents reinfection over many years.

46. (C) Tuberculosis (TB)
The Bacillus Calmette-Guérin BCG vaccine is a live-attenuated vaccine developed to confer active immunity against tuberculosis, an infection caused by Mycobacterium tuberculosis. Administered routinely at birth, BCG primarily protects young infants against severe systemic forms of tuberculosis, including tuberculous meningitis and disseminated miliary tuberculosis during early child growth developmental stages.

47. (D) Stopping antibiotic intake as soon as symptoms disappear
Prematurely halting a prescribed course of antibiotics when symptoms improve allows partially resistant bacteria to survive in the body. These surviving bacterial subpopulations resume multiplication and select for resistance traits. This incomplete treatment practice drives the evolutionary emergence and widespread

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biological antibiotics continuously

95. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Iodine deficiency in humans commonly leads to the enlargement of the thyroid gland, known as goitre.
Reason (R): Iodine is an essential structural component required for the synthesis of the thyroxine hormone.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

96. Which disease requires prolonged medical treatment of 6 months or more with a specific combination of anti-bacterial drugs known as DOTS (Directly Observed Treatment, Short-course)?
(A) Dengue
(B) Malaria
(C) Tuberculosis
(D) Cholera

97. Anemia predominantly affects which specific demographic group in developing nations, leading to major public health interventions?
(A) Adult males aged between 30 and 50 years
(B) Pregnant women and girls
(C) Elderly retired males over 70 years of age
(D) Professional high-performance athletes

98. Which of the following personal habits is most effective in preventing the spread of gastrointestinal and water-borne pathogens?
(A) Sleeping continuously for at least 8 to 10 hours every single night
(B) Brushing teeth thoroughly twice daily using fluoridated toothpaste
(C) Wearing a heavy-duty protective cloth face mask whenever going outdoors
(D) Washing hands with soap before eating and after toilet use

99. Identify the incorrect statement regarding the human immune system:
(A) It cannot differentiate between self and non-self.
(B) Innate immunity is inherently present in all humans from birth.
(C) Acquired adaptive immunity is highly pathogen-specific.
(D) Vaccination relies entirely on the memory property of the human immune system.

100. Consider the following Body Mass Index (BMI) categories:
I. Overweight
II. Obese
III. Normal weight
IV. Underweight
Which of the following options represents the correct increasing order of their values?
(A) I, II, III, IV
(B) IV, III, I, II
(C) IV, I, III, II
(D) III, IV, I, II

101. The phenomenon where a patient contracts a disease because a healthcare worker did not wash their hands between patients highlights a failure in:
(A) Personal and clinical hygiene
(B) Community nutritional interventions
(C) Standardized vaccination protocols
(D) Environmental vector control measures

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102. Which of the following is considered a primary cause of obesity?
(A) Performing excessive strenuous physical labor in agricultural work
(B) Experiencing a severe chronic deficiency of essential dietary protein
(C) Suffering from frequent, recurring viral and bacterial infections
(D) High calorie intake and lack of physical activity

103. In regions facing severe drought and water scarcity, local populations are at a higher risk of diseases related to:
(A) Severe hazards caused by excessive rainfall and sudden flooding
(B) Unsafe drinking water and poor sanitation
(C) Health complications from the overconsumption of fresh seafood
(D) Respiratory infections spread by extreme cold-weather viruses

104. What is the fundamental difference between communicable and non-communicable diseases?
(A) Non-communicable diseases are always fatal, while communicable ones are easily cured.
(B) Communicable diseases are caused by

structural components for cell growth and tissue maintenance. Protein is a macronutrient composed of amino acid chains, yielding four calories per gram. In contrast, iron, iodine, and vitamins represent micronutrients needed in smaller quantities.

58. (A) Vitamin D
Rickets is a skeletal bone disorder occurring in growing children due to insufficient Vitamin D, calcium, or phosphate levels. Vitamin D is essential for intestinal absorption of dietary calcium and phosphorus, which are needed for bone mineralization. Adequate sunlight exposure and dietary intake of Vitamin D prevent bone softening, bowing, and structural deformities.

59. (B) Dengue
Dengue fever is an acute mosquito-borne viral infection widely known as "breakbone fever" because of the severe joint, muscle, and bone pains it produces. Symptoms feature an abrupt high fever, intense retro-orbital headache, systemic rashes, myalgia, and severe arthralgia. In severe cases, dengue causes acute blood platelet drops, leading to vascular leakage.

60. (A) I and II only
Malaria is caused by protozoan parasites of the genus Plasmodium, which infect and multiply within human erythrocyte cells. However, transmission occurs through the bite of an infected female Anopheles mosquito, as female mosquitoes require blood meals to nourish developing eggs. Male mosquitoes feed exclusively on plant nectar, making the third statement incorrect.

61. (A) Excess fluoride in drinking water
Fluorosis is a public health disorder caused by chronic exposure to high concentrations of fluoride ions, primarily through contaminated drinking groundwater. Excessive fluoride accumulation leads to dental fluorosis, characterized by tooth enamel mottling, as well as skeletal fluorosis, which produces bone joint pain, ligament calcification, and severe skeletal crippling deformities.

62. (C) Deficiency of micronutrients despite adequate caloric intake
Hidden hunger describes a form of chronic undernutrition where an individual consumes sufficient total calories to avoid physical starvation but lacks adequate essential micronutrients, such as vitamins and minerals like iron, iodine, zinc, and vitamin A. Because overt clinical signs are not immediately apparent, hidden hunger stealthily impairs physical and cognitive health.

63. (D) Vector-borne diseases
Proper disposal of household wastewater and covering open drainage ditches remove stagnant water sources where mosquitoes like Anopheles, Aedes, and Culex lay eggs and breed. Eliminating vector breeding habitats directly controls insect vector populations in human residential areas, thereby significantly reducing community transmission rates of vector-borne infectious diseases like malaria and dengue.

64. (C) Marasmus
Marasmus is a severe form of protein-energy malnutrition caused by severe deficiency of both dietary protein and total calorie intake. Clinical manifestations include severe muscle wasting, prominent rib cage, extreme loss of subcutaneous body fat, thin spindly limbs, and an aged facial appearance, distinctively occurring without peripheral fluid accumulation or abdominal edema.

65. (B) Natural passive immunity
Natural passive immunity occurs when pre-formed protective antibodies are transferred naturally from mother to offspring without activating the infant's immune system to produce its own antibodies. In humans, maternal Secretory Immunoglobulin A (IgA) is transferred through breast milk and colostrum, protecting the infant's gastrointestinal lining against local mucosal microbial infections.

66. (D) Carrots and leafy green vegetables
Night blindness, or nyctalopia, is caused by Vitamin A deficiency, which impairs the synthesis of rhodopsin pigment in retinal rod cells. Dietary provitamin A carotenoids, such as beta-carotene, are abundant in yellow, orange, and dark green leafy vegetables like carrots and spinach. Consuming these plant foods restores Vitamin A levels and maintains normal vision.

67. (A) Pandemic
A pandemic is defined as an epidemic that spreads across international borders, affecting large populations across multiple countries or worldwide continents simultaneously. Unlike

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CHAPTER 20

Human Diseases: Causes and Cures

1. Which of the following diseases is classified as non-communicable?
(A) Tuberculosis
(B) Cholera
(C) Typhoid
(D) Diabetes mellitus

2. A disease that is transmitted from one person to another through contaminated water, food, or direct contact is known as a:
(A) Genetic disease
(B) Deficiency disease
(C) Communicable disease
(D) Degenerative disease

3. Identify the odd one out based on the mode of disease transmission.
(A) Malaria
(B) Scurvy
(C) Dengue
(D) Chikungunya

4. Match the diseases in List I with their causative pathogenic group in List II.
List I: Diseases
P. Ringworm
Q. Malaria
R. Typhoid
S. Common Cold
List II: Pathogens
1. Bacteria
2. Virus
3. Fungi
4. Protozoa
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-4, R-1, S-2

5. Down syndrome is a genetic disorder caused by the presence of an extra copy of which chromosome?
(A) Chromosome 21
(B) Chromosome 18
(C) X Chromosome
(D) Y Chromosome

6. Which of the following genetic diseases is an X-linked recessive disorder that impairs the body's ability to make blood clots?
(A) Sickle cell anemia
(B) Cystic fibrosis
(C) Hemophilia
(D) Huntington's disease

7. Sickle cell anemia is caused by a point mutation that results in the substitution of which amino acid in the beta-globin chain of hemoglobin?
(A) Glutamic acid by valine
(B) Valine by glutamic acid
(C) Glycine by alanine
(D) Serine by threonine

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8. Consider the following statements regarding genetic disorders:
I. Klinefelter syndrome occurs due to the presence of an additional X chromosome (47, XXY).
II. Turner syndrome is characterized by the absence of one X chromosome in females (45, X_0).
III. Colour blindness is a Y-linked dominant disorder.
Which of the combinations of the above statements is correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

9. Type 1 diabetes mellitus is primarily characterized by:
(A) Cellular insulin resistance occurring despite normal or elevated insulin levels
(B) Destruction of pancreatic beta cells causing absolute insulin deficiency
(C) Excessive production and systemic secretion of glucagon by pancreatic alpha cells
(D) Overproduction and secretion of functional insulin by pancreatic delta cells

10. The frequent urge to urinate, a common symptom of diabetes, is medically termed as:

77. (A) Providing safe water and sanitation infrastructure
Water-borne enteric diseases like cholera and typhoid spread through the fecal-oral route via contaminated water supplies. The most sustainable long-term public health solution involves establishing robust municipal water treatment systems, safe piped drinking water infrastructure, and proper sanitary waste disposal. This blocks environmental pathogen contamination, permanently preventing disease transmission across communities.

78. (C) Low height for a child's age due to poor growth
Stunting is a form of chronic undernutrition defined as a height-for-age value that falls below minus two standard deviations from world child growth standards. It reflects prolonged, cumulative nutritional deficits and recurrent childhood infections during early growth phases, permanently impairing a child's physical skeletal stature, physiological development, and long-term cognitive capabilities.

79. (D) They are purely genetic and cannot spread via air.
Communicable diseases are caused by transmissible biological pathogens, such as viruses, bacteria, protozoa, or fungi, rather than purely genetic mutations. Many communicable diseases, including tuberculosis and influenza, spread airborne via respiratory droplets. They transfer between hosts through direct contact, vectors, water, or air, and can be prevented using vaccines and proper public hygiene.

80. (A) Sporozoites enter blood → Multiplication in liver → Infection of red blood cells → Gametocyte formation
During a bite by an infected Anopheles mosquito, infective Plasmodium sporozoites are injected into human blood and migrate rapidly to liver hepatocytes. In the liver, sporozoites multiply asexual to form merozoites. Released merozoites invade red blood cells, undergoing cyclic schizogony to cause fever, with some merozoites differentiating into sexual gametocytes capable of infecting mosquitoes.

81. (B) Vitamin A
Vitamin A is chemically designated as Retinol, a fat-soluble essential micronutrient vital for vision, epithelial cell differentiation, immune function, and reproduction. Retinol is converted into retinal, which combines with opsin proteins in retinal rod cells to form rhodopsin. Deficiency of Retinol impairs light detection, leading directly to night blindness and xerophthalmia.

82. (D) Ringworm
Ringworm is a highly contagious fungal dermatophyte infection of the skin that spreads through direct physical skin-to-skin contact with infected individuals or indirectly via contaminated personal items like clothes, towels, and combs. Maintaining strict personal hygiene and avoiding shared personal items effectively prevents fungal spores from establishing infection on susceptible human skin.

83. (A) Poverty and lack of food purchasing power
Socio-economic poverty represents the single most significant root cause of persistent population-wide malnutrition. Low income levels severely restrict household purchasing power, preventing families from buying sufficient quantities of nutrient-rich foods such as proteins, dairy, fresh vegetables, and fruits. Economic constraints force reliance on cheap, nutrient-poor staple foods, promoting undernutrition and micronutrient deficiencies.

84. (C) Skin and mucous membranes
The skin and mucous membranes form the physical and chemical first line of defense in innate immunity against pathogen invasion. Intact keratinized skin forms a mechanical barrier preventing foreign entry, while mucous membranes lining the respiratory, digestive, and urogenital tracts produce mucus to trap microorganisms alongside antimicrobial enzymes like lysozyme to neutralize them.

85. (D) I, II and III
Dengue is an acute mosquito-borne viral infection caused by the dengue virus. Clinical presentation includes sudden high fever accompanied by severe retro-orbital pain, joint pain, and muscle pain, earning it the name breakbone fever. Laboratory diagnosis typically reveals severe thrombocytopenia, or a low platelet count, which can trigger hemorrhage in severe cases.

86. (D) Chlorine
Chlorination is the most widely utilized and cost-effective chemical method for disinfecting municipal public drinking water supplies.

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22. Genes that have the potential to cause cancer when mutated or expressed at high levels are known as:
(A) Suppressor genes
(B) Homeobox genes
(C) Oncogenes
(D) Promoter genes

23. Identify the correct statement regarding types of cancer.
(A) Carcinomas arise from the epithelial cells lining body surfaces.
(B) Sarcomas are malignancies arising primarily from epithelial tissue cells.
(C) Leukemias are malignant cancers originating in solid connective tissues.
(D) Lymphomas are malignant cancers originating exclusively in brain tissues.

24. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Benign tumors are generally considered non-cancerous and less dangerous than malignant tumors.
Reason (R): Benign tumors remain confined to their original location and do not spread to other body parts.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

25. Asthma is primarily a chronic respiratory disease characterized by:
(A) Acute bacterial infection affecting the pulmonary alveoli
(B) Inflammation and constriction of lower respiratory airways
(C) Progressive hardening and fibrotic scarring of lung tissue
(D) Irreversible destruction and rupture of alveolar wall tissue

26. Which part of the respiratory system is directly inflamed in a patient suffering from bronchitis?
(A) Alveoli
(B) Trachea
(C) Bronchi
(D) Pleura

27. Which chronic respiratory disorder is predominantly caused by long-term cigarette smoking, leading to the irreversible destruction of alveolar walls?
(A) Pneumonia
(B) Tuberculosis
(C) Diphtheria
(D) Emphysema

28. Consider the following statements about respiratory diseases:
I. Asthma involves difficulty in breathing causing wheezing due to inflammation of bronchi and bronchioles.
II. Occupational respiratory disorders like silicosis cause fibrosis of lung tissues.
III. Emphysema increases the respiratory surface area of the lungs.
Which of the combinations of the above statements is correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

29. Jaundice is a condition indicating the malfunction of which digestive organ, resulting in the buildup of bilirubin?
(A) Stomach
(B) Liver
(C) Pancreas
(D) Small intestine

30. Peptic ulcers in the stomach and duodenum are most commonly caused by an infection of which bacteria?
(A) Escherichia coli
(B) Helicobacter pylori
(C) Salmonella typhi
(D) Vibrio cholerae

31. Match the digestive system diseases in List I with their primary causes/characteristics in List II.
List I: Diseases
P. Cholera
Q. Typhoid
R. Constipation
S. Diarrhea
List II: Primary Causes/Characteristics
1. Feces are retained within the colon
2. Abnormal frequency of bowel movement and increased liquidity of fecal discharge
3. Contaminated water infection causing rice-water stools

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hormone production decreases, triggering compensatory hyper-stimulation by thyroid-stimulating hormone, which leads to physical enlargement of the thyroid gland, known as goitre.

96. (C) Tuberculosis
Tuberculosis requires prolonged medical treatment lasting six to nine months with combination antibacterial regimens under Directly Observed Treatment Short-course protocols. Using multiple first-line antitubercular drugs, such as isoniazid, rifampicin, pyrazinamide, and ethambutol, ensures complete bacterial clearance, prevents patient relapse, and stops the emergence of drug-resistant Mycobacterium tuberculosis strains during clinical therapy.

97. (B) Pregnant women and girls
Anemia predominantly affects adolescent girls and pregnant women in developing nations due to high physiological iron requirements. Menstruation increases regular iron loss in adolescent females, while pregnancy increases total blood volume and fetal oxygen demands. Consequently, inadequate dietary iron intake causes high rates of iron-deficiency anemia, prompting targeted iron and folic acid supplementation.

98. (D) Washing hands with soap before eating and after toilet use
Washing hands thoroughly with soap and clean water before consuming food and following toilet use is the most effective personal hygiene practice for interrupting the fecal-oral transmission of gastrointestinal and water-borne pathogens. Handwashing mechanically removes pathogenic bacteria, viruses, and parasite eggs from skin surfaces, preventing accidental ingestion and gastrointestinal infections.

99. (A) It cannot differentiate between self and non-self.
The fundamental property of the immune system is its ability to distinguish between "self" host tissues and "non-self" foreign antigenic molecules. Specific surface receptors on immune cells recognize self-antigens to maintain self-tolerance while mounting targeted responses against foreign non-self pathogens. Failure of self-discrimination results in autoimmune diseases where the immune system attacks host tissues.

100. (B) IV, III, I, II
Body Mass Index values categorize body weight relative to height into distinct sequential numerical ranges. Underweight represents the lowest BMI category below 18.5, followed by normal weight ranging from 18.5 to 24.9. Overweight spans BMI values from 25.0 to 29.9, while obese represents the highest category at 30.0 and above, establishing the order IV, III, I, II.

101. (A) Personal and clinical hygiene
Transmission of nosocomial pathogens between healthcare personnel and patients due to unwashed hands highlights a direct breakdown in personal and clinical hygiene standards. Proper clinical hand hygiene using antiseptic solutions or soap mechanically removes transmissible microorganisms from hands, serving as a primary infection control protocol to prevent healthcare-associated cross-contamination in clinical environments.

102. (D) High calorie intake and lack of physical activity
Obesity primarily arises from a persistent long-term positive energy balance, where daily caloric intake exceeds energy expenditure. Consuming high-calorie foods rich in fats and simple sugars, combined with a sedentary lifestyle and lack of physical activity, causes unused excess metabolic energy to be stored as fat in adipose tissue, leading to progressive obesity.

103. (B) Unsafe drinking water and poor sanitation
Drought and acute water scarcity force populations to rely on unsafe, unmanaged water sources, compromising personal and domestic hygiene. Lack of water for handwashing, sanitation facilities, and safe cooking dramatically increases the accumulation of microbial pathogens. This breakdown in sanitary conditions elevates the incidence of water-borne gastrointestinal infectious diseases like cholera, dysentery, and typhoid.

104. (C) Communicable diseases are infectious and can spread, while non-communicable diseases cannot.
Communicable diseases are caused by infectious biological pathogens, such as bacteria, viruses, fungi, or protozoa, that can be transmitted directly or indirectly from an infected host to a susceptible individual. Non-communicable

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localized endemic diseases, which remain present at stable baseline levels, or localized epidemics, which produce sudden localized spikes, pandemics involve global community transmission of newly emerging infectious pathogens.

68. (C) Plasmodium vivax – Malaria
Malaria is an infectious disease caused by protozoan parasites of the genus Plasmodium, including Plasmodium vivax and Plasmodium falciparum. In contrast, Vibrio cholerae causes cholera, Salmonella typhi causes typhoid fever, and Mycobacterium tuberculosis causes tuberculosis. Matching Plasmodium vivax with malaria correctly represents the biological relationship between the pathogen and disease.

69. (A) Prevention over cure
Public health strategy emphasizes prevention over cure as its primary foundational principle for managing communicable diseases. Preventive interventions, such as mass immunization, sanitation, clean water access, and vector control, are far more cost-effective and impact public health broadly compared to treating established cases, preventing widespread disease transmission, morbidity, and premature mortality.

70. (D) Both Assertion (A) and Reason (R) are false.
Both statements are false. Typhoid fever is transmitted through the fecal-oral route via food or water contaminated with Salmonella typhi, not by mosquito vector bites. Consequently, improving personal hygiene, safe drinking water access, and community sanitation infrastructure represents an extremely effective public health intervention to prevent typhoid infection and control transmission.

71. (B) Obesity and lifestyle diseases
Regular consumption of junk food, which is rich in added sugars, refined carbohydrates, and saturated fats, provides high caloric energy without essential dietary nutrients. This continuous calorie excess leads to positive energy balance and abnormal adipose tissue accumulation, directly promoting obesity and increasing long-term risks for cardiovascular diseases and type 2 diabetes.

72. (C) Proteins that recognize and neutralize foreign pathogens.
Antibodies, or immunoglobulins, are Y-shaped blood proteins produced by B lymphocytes in response to specific foreign antigens. They selectively bind to matching antigenic sites on viruses, bacteria, or toxic substances, neutralizing their biological activity or marking them for destruction by phagocytic immune cells like macrophages, thereby protecting the host from infection.

73. (D) Iron
Iron is an essential trace mineral required for synthesizing hemoglobin, the oxygen-carrying metalloprotein found in red blood cells. Iron binds molecular oxygen in the lungs and releases it to metabolizing body tissues. Inadequate dietary iron reduces functional hemoglobin synthesis, impairing oxygen delivery and resulting in iron-deficiency anemia, weakness, and fatigue.

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74. (A) Influenza
Influenza is an acute viral respiratory infection caused by influenza viruses, not a fungal disease. Conversely, athlete's foot, ringworm, and candidiasis are fungal infections caused by pathogenic fungi. Athlete's foot and ringworm are dermatophyte skin infections, while candidiasis is caused by Candida yeasts, affecting mucosal membranes and moist epidermal skin regions.

75. (B) P-4, Q-1, R-3, S-2
Mycobacterium tuberculosis is the bacterial pathogen causing tuberculosis. Vibrio cholerae is the bacterium causing cholera through water contamination. Salmonella typhi is the rod-shaped bacterium that produces typhoid fever. Plasmodium falciparum is the protozoan parasite causing malaria. Matching each pathogen with its respective clinical disease produces the sequence P-4, Q-1, R-3, S-2.

76. (B) Parasitic worms
Anthelmintic medications are antiparasitic drugs formulated to treat helminth infections caused by parasitic worms, such as roundworms, hookworms, tapeworms, and whipworms. These drugs eradicate intestinal and tissue-dwelling worms by inhibiting microtubule polymerization, blocking glucose uptake, or causing neuromuscular paralysis in parasites, facilitating their rapid expulsion from host human body tissues.

114. (D) It spreads airborne respiratory pathogens like tuberculosis.
Public spitting presents a major environmental public health risk because respiratory secretions contain infectious pathogens. Individuals with active pulmonary tuberculosis exhale Mycobacterium tuberculosis in sputum. Spitting deposits live bacteria onto public ground surfaces, where dried sputum forms infectious droplet nuclei that aerosolize into ambient air, exposing susceptible passersby to airborne infection when inhaled.

115. (A) Warm and moist
Pathogenic dermatophyte fungi responsible for infections like ringworm and athlete's foot thrive in warm, moist environments. Elevated humidity and warm skin temperatures promote fungal spore germination, hyphal growth, and cellular multiplication on keratinized epidermal tissue layers. Body regions that retain moisture, such as sweaty skin folds and interdigital foot spaces, are especially susceptible.

116. (C) Iodine
Iodine is an essential micronutrient required for synthesizing thyroid hormones, which regulate fetal and early childhood neurological development. Chronic iodine deficiency during gestation and childhood impairs brain formation, causing congenital hypothyroidism, permanent cognitive impairment, reduced IQ levels, impaired learning capacity, and growth retardation in developing young children across vulnerable population groups.

117. (A) Polio
Poliomyelitis is a highly infectious viral disease caused by poliovirus that attacks the central nervous system, causing irreversible paralysis or death. Effective childhood vaccines, including the Oral Polio Vaccine and Inactivated Polio Vaccine, stimulate mucosal and systemic immunity against all poliovirus serotypes, enabling global public health efforts to achieve near-total disease eradication.

118. (D) Due to unhealthy diets, physical inactivity, and tobacco use
Non-communicable diseases, such as cardiovascular diseases, type 2 diabetes, chronic respiratory conditions, and cancers, are rising globally due to shifting lifestyle patterns. Rapid urbanization, sedentary daily routines, widespread tobacco use, excessive alcohol consumption, and unhealthy diets high in processed fats and refined sugars drive metabolic risk factors, increasing chronic disease burden.

119. (B) Having a child with neural tube defects
Folic acid, or Vitamin B9, is essential during early pregnancy for cellular division, nucleic acid synthesis, and proper closure of the neural tube in developing embryos. Inadequate maternal intake of folic acid prior to conception and during early gestation elevates the risk of congenital neural tube defects, including spina bifida and anencephaly.

120. (C) Imbalance between nutrients needed by the body and nutrients received
Malnutrition is medically defined as a physiological imbalance between the quantity and quality of nutrients required by the body for optimal metabolic growth and the nutrients actually received. This condition encompasses undernutrition, characterized by stunting, wasting, and micronutrient deficiencies, as well as overnutrition, characterized by excessive caloric consumption leading to overweight and obesity.

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diseases are non-infectious health conditions caused by genetic, physiological, environmental, and behavioral lifestyle factors, and cannot be transmitted between human individuals.

105. (D) P-3, Q-4, R-1, S-2
POSHAN Abhiyaan aims to reduce stunting, undernutrition, and anemia. The Mid-Day Meal Scheme improves child nutritional status and school attendance. Swachh Bharat Mission targets community sanitation and ending open defecation. The Universal Immunization Programme prevents vaccine-preventable childhood diseases. Matching these public health programs to their primary objectives yields P-3, Q-4, R-1, and S-2.

106. (A) Fats
Dietary fats are the most energy-dense macronutrients, yielding approximately nine kilocalories per gram. In comparison, both carbohydrates and proteins provide four kilocalories per gram. Water contains no energy value. Because fat molecules are highly reduced hydrocarbons, their metabolic oxidation releases more than twice the chemical energy per gram than carbohydrates or proteins.

107. (B) Blue baby syndrome
Agricultural runoff from synthetic fertilizers and uncontained sewage contamination introduce excess nitrates into groundwater drinking supplies. When ingested by infants, intestinal bacteria convert nitrates into nitrites. Nitrites oxidize hemoglobin into methemoglobin, which cannot bind oxygen. This condition, methemoglobinemia or blue baby syndrome, restricts oxygen transport, resulting in cyanosis, tissue hypoxia, and respiratory distress.

108. (B) Comma-shaped bacterium
Vibrio cholerae is morphologically classified as a comma-shaped, Gram-negative, motile rod bacterium possessing a single polar flagellum. It infects the human small intestine via ingested contaminated water or food, producing cholera toxin. This enterotoxin disrupts mucosal ion channels, triggering severe hypersecretion of water and electrolytes, leading to rapid severe dehydration.

109. (A) Synthetic food coloring
Synthetic food coloring additives are artificial non-nutritive chemical dyes used solely to alter appearance and aesthetic appeal. They provide no nutritional value, metabolic energy, or biological function, and are not essential for health. In contrast, carbohydrates, vitamins, minerals, and roughage represent essential components of a balanced diet necessary for normal body maintenance.

110. (D) I, II and III
Antibiotic resistance develops when bacterial strains undergo genetic mutations or acquire resistance genes that enable survival against therapeutic antibiotics. Overusing and misusing antibiotics in clinical medicine and livestock agriculture accelerates this evolutionary selection process. Consequently, resistant bacterial infections become difficult or impossible to treat with standard antimicrobial drugs, increasing clinical severity.

111. (D) Further ingestion of bacteria from contaminated sources
Typhoid fever is caused by Salmonella typhi, which spreads via food and water contaminated with human fecal material. Patients recovering from typhoid are advised to drink boiled water and consume cooked food to eliminate microbial pathogens in food and fluids. This prevents reinfection or secondary ingestion of additional bacterial pathogens during recovery.

112. (C) Anopheles
Biological transmission of the malaria parasite Plasmodium occurs exclusively through mosquito vectors belonging to the genus Anopheles. Specifically, female Anopheles mosquitoes serve as definitive hosts and vectors, acquiring gametocytes during blood meals and injecting sporozoites into humans. In contrast, Aedes transmits dengue and Culex transmits filariasis, while Phlebotomus sandflies transmit Kala-azar.

113. (B) Rabies
Rabies is a fatal viral zoonotic disease caused by the rabies lyssavirus, affecting the central nervous system. It is transmitted to humans through saliva when an infected animal, such as a rabid dog, bites or scratches a susceptible host. The virus travels along peripheral nerves to the brain, producing fatal encephalomyelitis unless post-exposure prophylaxis is administered promptly.

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(A) Polydipsia
(B) Polyphagia
(C) Polyuria
(D) Glycosuria

11. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Patients with severe diabetes often excrete glucose in their urine.
Reason (R): In diabetes, the blood glucose level drops so low that the kidneys excrete it to maintain balance.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

12. Which hormone lowers blood glucose levels by facilitating cellular uptake of glucose?
(A) Insulin
(B) Glucagon
(C) Adrenaline
(D) Thyroxine

13. A normal healthy adult human has an average resting blood pressure of approximately:
(A) 140/90 mmHg
(B) 120/80 mmHg
(C) 100/60 mmHg
(D) 160/100 mmHg

14. Which of the following is NOT a common risk factor for primary hypertension?
(A) High sodium dietary intake
(B) Regular aerobic exercise
(C) Severe clinical obesity
(D) Chronic psychological stress

15. The medical instrument used to measure human blood pressure is called a:
(A) Sphygmomanometer
(B) Stethoscope
(C) Electrocardiograph
(D) Barometer

16. Select the correct sequence of blood flow through the human heart from the options below:
(A) Left Atrium → Left Ventricle → Lungs → Right Atrium → Right Ventricle
(B) Right Ventricle → Right Atrium → Lungs → Left Ventricle → Left Atrium
(C) Right Atrium → Right Ventricle → Lungs → Left Atrium → Left Ventricle
(D) Right Atrium → Left Atrium → Lungs → Right Ventricle → Left Ventricle

17. The cardiovascular condition characterized by the buildup of cholesterol, fats, and other substances in and on the artery walls is known as:
(A) Aneurysm
(B) Arrhythmia
(C) Endocarditis
(D) Atherosclerosis

18. A "myocardial infarction" is the medical term for which common cardiovascular event?
(A) Stroke
(B) Cardiac arrest
(C) Heart attack
(D) Heart murmur

19. Match the ECG waves in List I with their corresponding cardiac events in List II.
List I: ECG Waves
P. P wave
Q. QRS complex
R. T wave
S. Flat line (Isoelectric)
List II: Cardiac Events
1. Depolarization of ventricles
2. Repolarization of ventricles
3. Depolarization of atria
4. Resting state
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-2, R-1, S-4

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20. Which type of cholesterol is commonly referred to as "good cholesterol" because it helps remove other forms of cholesterol from the bloodstream?
(A) Low-Density Lipoprotein (LDL)
(B) Very Low-Density Lipoprotein (VLDL)
(C) Triglycerides
(D) High-Density Lipoprotein (HDL)

21. The process by which cancer cells spread from the primary site to other parts of the body through the bloodstream or lymphatic system is called:
(A) Metastasis
(B) Apoptosis
(C) Mutation
(D) Angiogenesis

Adding chlorine or hypochlorite compounds to raw water destroys pathogenic bacteria, viruses, and unicellular micro-organisms by oxidizing cellular membranes and enzyme systems, thereby effectively eradicating water-borne disease pathogens such as Vibrio cholerae bacterial strains.

87. (B) Thiamine (Vitamin B_1)
Beriberi is a metabolic deficiency disease resulting from insufficient dietary intake of Thiamine, chemically known as Vitamin B_1. Thiamine serves as a crucial coenzyme in cellular carbohydrate metabolism and energy production. Its deficiency causes neurological impairment, muscle weakness, and peripheral nerve damage in dry beriberi, or cardiovascular failure and edema in wet beriberi.

88. (C) Citrus fruits
Citrus fruits—including oranges, lemons, limes, and grapefruits—are rich natural dietary sources of Vitamin C, chemically known as ascorbic acid. Vitamin C is a water-soluble antioxidant vitamin essential for collagen synthesis, immune function, tissue repair, and enhancing dietary iron absorption. Regular consumption of fresh citrus fruits effectively prevents clinical deficiency conditions like scurvy.

89. (D) Ability of a microorganism to cause disease
Pathogenicity refers to the qualitative genetic capacity of a microscopic pathogen—such as a specific bacterium, virus, fungus, or protozoan—to infect a host organism and cause disease. It differs from virulence, which measures the quantitative degree of pathology produced. Pathogenicity depends on biological mechanisms including host entry, cell tissue invasion, and toxin production.

90. (A) P-3, Q-4, R-2, S-1
Active natural immunity develops following recovery from a natural clinical infection. Active artificial immunity is acquired through administration of vaccines. Passive natural immunity involves transferring maternal antibodies through breast milk colostrum to infants. Passive artificial immunity results from injecting pre-formed antiserum or monoclonal antibodies. This establishes the matching order as P-3, Q-4, R-2, and S-1.

91. (B) Dengue
The Aedes aegypti mosquito serves as the primary urban vector transmitting the dengue virus. Aedes mosquitoes prefer breeding in artificial water containers found in domestic settings. Public health interventions targeting the elimination of standing water sources, clearing unsealed water containers, and applying larvicides eliminate Aedes breeding grounds, suppressing local vector populations and controlling dengue transmission.

92. (B) Tuberculosis
Tuberculosis is an infectious, communicable bacterial disease caused by Mycobacterium tuberculosis, which spreads between individuals through airborne respiratory droplets. In contrast, diabetes, obesity, and hypertension represent non-communicable, non-infectious metabolic disorders that develop due to complex genetic, environmental, and lifestyle factors without involving transmissible pathogenic microbial disease viral or bacterial infection.

93. (A) Diphtheria, Pertussis, Tetanus
The DPT vaccine is a combination vaccine administered in childhood to provide protective immunity against three severe bacterial diseases: diphtheria, pertussis, and tetanus. Diphtheria is caused by Corynebacterium diphtheriae, pertussis by Bordetella pertussis, and tetanus by Clostridium tetani toxins. Inoculation stimulates specific neutralizing antibody production against all three bacterial pathogens.

94. (C) To mount a rapid immune response upon re-exposure
Memory B-cells and T-cells are long-lived, antigen-specific lymphocytes generated during a primary immune response. They persist in lymphatic tissues and provide immunological memory. Upon secondary exposure to the same pathogen, memory cells recognize the antigen quickly, proliferating rapidly into effector cells that produce antibodies and launch targeted defenses to eliminate the pathogen.

95. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Both statements are true, and the reason correctly explains the assertion. Iodine is an essential mineral required by thyroid follicular cells to synthesize thyroxine and triiodothyronine. When dietary iodine intake is inadequate, thyroid

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4. Widal test is used for its diagnosis
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-1, R-4, S-3

32. Severe diarrhea often requires immediate oral rehydration therapy. What is the standard abbreviation for the solution used?
(A) ORP
(B) ODT
(C) ORS
(D) OHR

33. The process of hemodialysis is utilized as an artificial replacement for lost kidney function. It operates primarily on the principle of:
(A) Active trans-membrane transport
(B) Receptor-mediated endocytosis
(C) Capillary action and absorption
(D) Passive osmosis and diffusion

34. The accumulation of toxic levels of urea in the blood due to kidney failure is clinically termed:
(A) Hematuria
(B) Glycosuria
(C) Uremia
(D) Proteinuria

35. Renal calculi, commonly known as kidney stones, are predominantly composed of crystallized salts of:
(A) Sodium chloride
(B) Calcium oxalate
(C) Potassium nitrate
(D) Magnesium sulfate

36. Consider the following two statements regarding kidney function:
Statement I: Antidiuretic Hormone (ADH) facilitates water reabsorption from the latter parts of the kidney tubule.
Statement II: A deficiency of ADH leads to a condition called diabetes insipidus, characterized by excessive water loss in urine.
(A) Statement I is true, Statement II is false
(B) Statement I is false, Statement II is true
(C) Both Statement I and Statement II are true
(D) Both Statement I and Statement II are false

37. Which of the following is the causative agent of the sexually transmitted disease Syphilis?
(A) Treponema pallidum
(B) Neisseria gonorrhoeae
(C) Chlamydia trachomatis
(D) Human papillomavirus

38. Which of the following sexually transmitted diseases is viral in origin and currently incurable, though manageable with antiviral drugs?
(A) Syphilis
(B) Gonorrhea
(C) Genital herpes
(D) Chlamydiasis

39. Match the Sexually Transmitted Diseases (STDs) in List I with their pathogen types in List II.
List I: STDs
P. Gonorrhea
Q. Trichomoniasis
R. Genital Warts
S. AIDS
List II: Pathogen Types
1. Retrovirus
2. DNA Virus
3. Bacteria
4. Protozoa
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-4, R-2, S-3

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40. Identify the incorrect statement regarding the prevention of sexually transmitted diseases.
(A) Consistent use of condoms during intercourse reduces the risk of STDs.
(B) Early diagnosis and treatment are crucial to prevent complications.
(C) Avoiding sexual contact with unknown or multiple partners is a preventative measure.
(D) Sharing of injection needles does not transmit STDs under any circumstances.

41. The Human Immunodeficiency Virus (HIV) primarily targets and destroys which specific cells of the human immune system?
(A) Erythrocytes (Red Blood Cells)
(B) CD^{4+} T-helper cells
(C) Platelets
(D) B-memory cells

42. Which diagnostic test is widely used as an initial screening tool for detecting HIV antibodies in the blood?
(A) Widal test
(B) PCR test
(C) ELISA test
(D) Mantoux test

List I: Disorders
P. Acrophobia
Q. Insomnia
R. Anorexia nervosa
S. Claustrophobia
List II: Descriptions
1. Eating disorder involving extreme weight loss
2. Chronic inability to sleep
3. Extreme fear of confined spaces
4. Extreme fear of heights
(A) P-3, Q-1, R-2, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-3, R-4, S-1

65. Which hormone, produced by the adrenal cortex, is commonly known as the "stress hormone" due to its role in the body's response to prolonged stress?
(A) Melatonin
(B) Thyroxine
(C) Oxytocin
(D) Cortisol

66. During an acute stressful situation, the "fight or flight" response is immediately triggered by the:
(A) Parasympathetic nervous system
(B) Somatic nervous system
(C) Sympathetic nervous system
(D) Enteric nervous system

67. Chronic stress has a scientifically proven negative impact on physical health primarily by:
(A) Increasing bone density
(B) Suppressing the immune system
(C) Enhancing liver detoxification
(D) Decreasing resting heart rate permanently

68. Consider the following statements regarding stress management techniques:
I. Meditation and deep breathing reduce sympathetic nervous system activity.
II. Regular physical exercise helps reduce cortisol and adrenaline levels in the blood.
III. Consuming high amounts of caffeine is an effective long-term strategy for stress reduction.
Which of the combinations of the above statements is correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

69. Opioid drugs, such as morphine, bind to specific opioid receptors primarily present in our:
(A) Central nervous system and gastrointestinal tract
(B) Peripheral respiratory and renal excretory systems
(C) Skeletal muscle tissue and synovial joint cavities
(D) Major endocrine glands and hormone-secreting organs

70. The illegal drug commonly known as "smack" or heroin is chemically a derivative of morphine. What is its chemical name?
(A) Methylmorphine
(B) Tetrahydrocannabinol
(C) Diacetylmorphine
(D) Lysergic acid diethylamide

71. Cocaine, an alkaloid obtained from the coca plant, produces a strong stimulating action by primarily interfering with the transport of which neurotransmitter?
(A) Dopamine
(B) Acetylcholine
(C) Glycine
(D) Histamine

72. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Repeated use of addictive drugs increases the tolerance level of receptors present in our body.
Reason (R): Consequently, the receptors respond only to higher doses of drugs, leading to greater intake and addiction.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

73. Tobacco contains a highly addictive chemical substance which stimulates the adrenal gland to release adrenaline. This chemical is:
(A) Caffeine
(B) Nicotine
(C) Tannin
(D) Theobromine

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53. The transfer of antibodies from a mother to her infant through breast milk (colostrum) provides which type of immunity?
(A) Naturally acquired passive immunity
(B) Naturally acquired active immunity
(C) Artificially acquired active immunity
(D) Artificially acquired passive immunity

54. The BCG (Bacillus Calmette-Guérin) vaccine is administered to infants to provide protection against:
(A) Acute poliomyelitis
(B) Diphtheria infection
(C) Tuberculosis disease
(D) Measles virus infection

55. Match the vaccines in List I with the target diseases in List II.
List I: Vaccines
P. DPT
Q. OPV
R. MMR
S. TT
List II: Target Diseases
1. Measles, Mumps, Rubella
2. Diphtheria, Pertussis, Tetanus
3. Tetanus Toxoid
4. Polio
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-4, S-3

56. Arrange the following cellular events of the immune response in the correct chronological order:
1. Production of specific antibodies by B-cells
2. Entry of the pathogen into the body
3. Engulfment of the pathogen by macrophages
4. Presentation of antigens to Helper T-cells
(A) 2 - 4 - 3 - 1
(B) 3 - 2 - 4 - 1
(C) 2 - 1 - 3 - 4
(D) 2 - 3 - 4 - 1

57. The concept of "Health for All" and primary healthcare was globally formalized in 1978 during the:
(A) Geneva Convention
(B) Alma-Ata Declaration
(C) Kyoto Protocol
(D) Paris Agreement

58. Under India's National Health Mission, what does the acronym ASHA stand for?
(A) Auxiliary Social Health Assistant
(B) Association of State Health Administrators
(C) Accredited Social Health Activist
(D) Advanced Surgical Healthcare Assistant

59. Which flagship health insurance scheme by the Government of Rajasthan aims to provide cashless medical facilities to families for major illnesses?
(A) PM Kisan Samman Nidhi
(B) Mahatma Gandhi NREGA
(C) Indira Rasoi Yojana
(D) Mukhyamantri Chiranjeevi Swasthya Bima Yojana

60. Identify the correct statement distinguishing a Primary Health Centre (PHC) from a Community Health Centre (CHC).
(A) A CHC acts as a referral unit for several PHCs and has specialist doctors.
(B) A PHC generally serves a population of 1,00,000, while a CHC serves 10,000.
(C) Only CHCs are authorized to administer vaccines.
(D) PHCs are located only in urban areas, while CHCs are in rural areas.

61. A severe mental disorder characterized by a breakdown in thought processes, poor emotional responsiveness, and hallucinations is known as:
(A) Bipolar disorder
(B) Schizophrenia
(C) Obsessive-compulsive disorder (OCD)
(D) Dyslexia

62. The mental health condition primarily characterized by persistent feelings of sadness, loss of interest, and lack of energy is:
(A) Generalised Anxiety Disorder
(B) Clinical Depression
(C) Claustrophobia
(D) Post-Traumatic Stress Disorder

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63. Which neurotransmitter in the brain is most commonly associated with mood regulation, and its deficiency is linked to depression?
(A) Serotonin
(B) Acetylcholine
(C) GABA
(D) Glutamate

64. Match the mental or sleep-related disorders in List I with their descriptions in List II.

43. Arrange the following events of the HIV replication cycle in the correct chronological order:
1. Integration of viral DNA into host genome
2. Viral attachment and entry into the host cell
3. Assembly and release of new viral particles
4. Reverse transcription of viral RNA to DNA

(A) 2 - 1 - 4 - 3
(B) 4 - 2 - 1 - 3
(C) 1 - 2 - 4 - 3
(D) 2 - 4 - 1 - 3

44. HIV can be transmitted through all of the following routes EXCEPT:
(A) Sharing food and utensils with an infected person
(B) Unprotected sexual intercourse with an infected person
(C) Transfusion of contaminated blood
(D) From an infected mother to her child during pregnancy or breastfeeding

45. In medical diagnostics, what does the acronym MRI stand for?
(A) Medical Radiation Instrument
(B) Magnetic Resonance Imaging
(C) Magnetic Radiation Imaging
(D) Medical Resonance Imaging

46. The Widal test is a common serological diagnostic method used to confirm the presence of which disease?
(A) Pulmonary tuberculosis
(B) Acute typhoid fever
(C) Severe malarial fever
(D) Bacterial pneumonia

47. Consider the following statements about disease diagnostic methods:
I. A biopsy involves the removal of a small piece of tissue for microscopic examination to detect cancer.
II. An endoscope is an optical instrument used to examine the interior of hollow organs.
III. Ultrasound imaging utilizes high-frequency X-rays to create images of internal body structures.

Which of the combinations of the above statements is correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

48. An Electroencephalogram (EEG) is a diagnostic test primarily used to record the electrical activity of the:
(A) Heart
(B) Skeletal muscles
(C) Brain
(D) Retina

49. Introducing Gambusia fish into local water bodies is a biological control strategy for:
(A) Biological filtration for urban water purification
(B) Increasing economic yields in local commercial fisheries
(C) Removing hazardous toxic heavy metals from local ponds
(D) Direct mosquito larvae control to prevent malaria spread

50. The process of pasteurization of milk involves heating it to specific temperatures to kill pathogenic bacteria. This method was discovered by:
(A) Robert Koch
(B) Alexander Fleming
(C) Louis Pasteur
(D) Edward Jenner

51. Which of the following is considered a method of primary disease prevention?
(A) Chemotherapy treatment for a diagnosed cancer patient
(B) Routine administration of a Hepatitis B vaccine
(C) Periodic routine mammography screening for early detection
(D) Long-term physical therapy rehabilitation after a stroke

52. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Boiling drinking water is an effective household method to prevent waterborne diseases.
Reason (R): Boiling water at 100°C destroys the cell structure and enzymes of most pathogenic bacteria and viruses.
(A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
(B) Both Assertion (A) and Reason (R) are true but R is not the correct explanation of A.
(C) Assertion (A) is true but Reason (R) is false.
(D) Assertion (A) is false but Reason (R) is true.

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74. Smoking increases the concentration of carbon monoxide (CO) in the blood. This is harmful because CO:
(A) Rapidly destroys circulating white blood cells and platelets
(B) Triggers immediate and severe blood clotting in arteries
(C) Reduces the oxygen-carrying capacity of hemoglobin
(D) Rapidly converts into toxic carbon dioxide in heart tissue

75. Chewing tobacco instead of smoking it is most directly linked to a high incidence of which type of cancer?
(A) Primary lung cancer
(B) Malignant prostate cancer
(C) Primary brain cancer
(D) Oral cavity cancer

76. Select the correct sequence of the air passage in humans during inhalation.
(A) Nostrils → Pharynx → Larynx → Trachea → Bronchi → Alveoli
(B) Nostrils → Larynx → Pharynx → Trachea → Bronchi → Alveoli
(C) Nostrils → Trachea → Pharynx → Larynx → Bronchi → Alveoli
(D) Nostrils → Pharynx → Trachea → Larynx → Bronchi → Alveoli

77. Chronic and excessive alcohol consumption primarily leads to severe damage and scarring of the liver, a condition known as:
(A) Viral Hepatitis A
(B) Liver Cirrhosis
(C) Acute Pancreatitis
(D) Chronic Cholecystitis

78. The primary active chemical ingredient in alcoholic beverages that affects the central nervous system is:
(A) Ethanol
(B) Methanol
(C) Isopropyl alcohol
(D) Butanol

79. Alcohol consumption during pregnancy can cause severe physical and mental defects in the developing baby. This condition is termed:
(A) Fetal Alcohol Syndrome (FAS)
(B) Down Syndrome
(C) Sudden Infant Death Syndrome (SIDS)
(D) Turner Syndrome

80. Match the substances in List I with their primary physiological effect or classification in List II.
List I: Substances
P. Alcohol
Q. Caffeine
R. LSD
S. Marijuana
List II: Physiological Effect / Classification
1. Hallucinogen
2. Depressant
3. Cannabinoid
4. Stimulant
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-3, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-1, Q-3, R-2, S-4

81. High-intensity exercise without sufficient oxygen supply is termed anaerobic. Which acid accumulates in muscles during anaerobic exercise causing fatigue?
(A) Acetic acid
(B) Citric acid
(C) Pyruvic acid
(D) Lactic acid

82. Body Mass Index (BMI) is an important metric for evaluating a healthy lifestyle. What is the standard formula for calculating BMI?
(A) Total weight in kg / (Height in meters)
(B) (Height in meters)^2 / Total weight in kg
(C) Weight in kg / (Height in meters)^2
(D) Weight in lbs / (Height in inches)^2

83. According to the World Health Organization (WHO), a BMI value within which range is generally considered "Normal weight" for adults?
(A) 14.5 to 18.4
(B) 18.5 to 24.9
(C) 25.0 to 29.9
(D) 30.0 to 34.9

84. Identify the INCORRECT statement regarding a sedentary lifestyle.
(A) It significantly increases the long-term risk of cardiovascular diseases.
(B) It noticeably lowers the body's natural resting basal metabolic rate.
(C) It serves as a primary contributing risk factor for developing obesity.
(D) It improves insulin sensitivity, reducing the risk of Type 2 diabetes.

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ANSWERS

1. (D) Diabetes mellitus
Diabetes mellitus is a metabolic condition characterized by high blood sugar levels over prolonged periods. Unlike infectious diseases, non-communicable diseases cannot be transmitted directly or indirectly from one individual to another. They typically arise from genetic predispositions, physiological factors, environmental exposures, and lifestyle choices such as poor diet and physical inactivity.

2. (C) Communicable disease
Infectious disorders capable of spreading between human hosts or from animals to humans are categorized as communicable diseases. These pathogens pass through various transmission modes, including contaminated water, food, direct physical contact, airborne respiratory droplets, or intermediate vectors. Understanding these pathways is essential for implementing effective public health containment and prevention measures.

3. (B) Scurvy
Scurvy is a nutritional deficiency disease resulting from an inadequate dietary intake of vitamin C, which is essential for collagen synthesis. It cannot be transmitted from person to person. In contrast, infectious conditions like malaria, dengue, and chikungunya rely on biological insect vectors for biological transmission between human populations in endemic regions.

4. (D) P-3, Q-4, R-1, S-2
Human infectious diseases are caused by distinct taxonomic categories of microscopic pathogens. Ringworm is a fungal infection affecting skin structures. Malaria is caused by protozoan parasites of the genus Plasmodium. Typhoid fever stems from the bacterium Salmonella typhi. The common cold is an acute viral infection primarily triggered by common human rhinoviruses.

5. (A) Chromosome 21
Down syndrome, medically recognized as trisomy 21, is a human genetic disorder caused by nondisjunction during gamete formation. This meiotic error leads to three copies of chromosome 21 instead of two. Affected individuals manifest distinctive facial features, mild to moderate intellectual disability, physical growth delays, and elevated risks for cardiac defects.

6. (C) Hemophilia
Hemophilia is an X-linked recessive genetic disorder characterized by deficiency in specific blood clotting factors, such as Factor VIII or IX. Because males possess a single X chromosome, inheriting one mutated gene causes the disease. Affected individuals experience prolonged bleeding following minor injuries, spontaneous joint hemorrhages, and impaired internal coagulation.

7. (A) Glutamic acid by valine
Sickle cell anemia is caused by a point mutation in the HBB gene encoding the beta-globin chain of hemoglobin. Specifically, adenine is replaced by thymine in the GAG codon, substituting hydrophilic glutamic acid with hydrophobic valine at the sixth position. This structural modification causes abnormal hemoglobin polymerization under low oxygen tension.

8. (A) I and II only
Klinefelter syndrome is a chromosomal disorder in males characterized by an extra X chromosome, resulting in a 47, XXY karyotype. Turner syndrome affects females due to partial or complete monosomy of the X chromosome, yielding a 45, X_0 karyotype. Colour blindness is actually an X-linked recessive genetic trait rather than Y-linked dominant.

9. (B) Destruction of pancreatic beta cells causing absolute insulin deficiency
Type 1 diabetes mellitus is an autoimmune disorder wherein the body's immune system mistakenly targets and destroys pancreatic beta cells located within the islets of Langerhans. This destruction abolishes internal insulin synthesis, leading to absolute insulin deficiency. Patients require lifelong exogenous insulin therapy to regulate glucose metabolism and maintain cellular homeostasis.

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(A) Distributing free digital smartphones to rural public healthcare workers
(B) Building large-scale state-of-the-art private hospitals in urban centers
(C) Preventive healthcare, lifestyle modification, and public health awareness
(D) Systematically privatizing primary and secondary healthcare service centers

97. The National Vector Borne Disease Control Programme (NVBDCP) in India provides strategies to control which of the following set of diseases?
(A) Pulmonary TB, Cholera, and Typhoid
(B) Acute Polio, Measles, and Rubella
(C) Chronic HIV/AIDS and Syphilis
(D) Malaria, Dengue, and Chikungunya

98. Which digital platform was widely deployed by the Government of India for the public registration and management of the COVID-19 vaccination drive?
(A) eSanjeevani
(B) Aarogya Setu Tracker
(C) CoWIN
(D) NIKSHAY

99. The specialized agency of the United Nations responsible for international public health is the:
(A) UNICEF
(B) WHO
(C) UNESCO
(D) FAO

100. To raise global awareness about health issues, World Health Day is celebrated annually on:
(A) 1st December
(B) 5th June
(C) 21st June
(D) 7th April

101. The "Red Ribbon" is an internationally recognized symbol used for awareness and support regarding which disease?
(A) HIV/AIDS
(B) Breast Cancer
(C) Polio
(D) Tuberculosis

102. Which of the following is the most appropriate description of the primary goal of health education?
(A) To diagnose complex underlying medical conditions accurately without clinical testing
(B) To inform the public about self-medication strategies to avoid visiting physicians
(C) To enable individuals to adopt healthy choices and make informed lifestyle decisions
(D) To legally enforce strict administrative punishments for poor personal health choices

103. Identify the correct statement about the role of mass media in public health.
(A) Mass media rapidly disseminates key information during epidemic outbreaks.
(B) Mass media channels consistently reduce the overall reach of public health schemes.
(C) Mass media interventions are effective exclusively for treatment rather than prevention.
(D) Mass media campaigns demonstrate no measurable impact on personal health behaviors.

104. A common age-related condition characterized by a progressive loss of bone density, making bones fragile and more prone to fractures, is:
(A) Osteoarthritis
(B) Gout
(C) Muscular dystrophy
(D) Osteoporosis

105. Alzheimer's disease, a common ailment in old age, primarily causes the progressive degeneration of which body system?
(A) Central cardiovascular system
(B) Nervous system (Brain)
(C) Peripheral excretory system
(D) Lower respiratory system

106. The age-related loss of the eye lens's ability to focus on nearby objects, often requiring reading glasses in older adults, is known as:
(A) Myopia
(B) Hypermetropia
(C) Presbyopia
(D) Astigmatism

107. Cataract, a major cause of blindness in the elderly, involves:
(A) Abnormally elevated intraocular fluid pressure within the eyeball
(B) Progressive damage and degeneration of the posterior optic nerve
(C) Partial or complete mechanical detachment of the ocular retina
(D) Progressive clouding and opacity of the natural crystalline lens

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85. Which water-soluble vitamin, also known as Ascorbic acid, is essential for tissue repair and a strong immune system?
(A) Vitamin C
(B) Vitamin A
(C) Vitamin B_{12}
(D) Vitamin D

86. The primary cells responsible for fighting infections and providing cellular immunity in the human body are the:
(A) Erythrocytes
(B) Thrombocytes
(C) Leukocytes
(D) Osteocytes

87. Consider the following statements regarding immunity-boosting micronutrients:
I. Vitamin D plays a crucial role in enhancing the pathogen-fighting effects of immune cells.
II. Zinc is essential for immune cell development and communication.
III. Iron deficiency leads to an overactive immune response.
Which of the combinations of the above statements is correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II, and III

88. Which primary lymphoid organ is situated near the heart and is the site for the maturation of T-lymphocytes?
(A) Spleen
(B) Bone Marrow
(C) Thyroid
(D) Thymus

89. A routine health check-up procedure called mammography uses low-energy X-rays to screen primarily for:
(A) Lung cancer
(B) Breast cancer
(C) Bone density loss
(D) Stomach ulcers

90. A "Lipid Profile" blood test is commonly recommended to measure the levels of:
(A) Hemoglobin and red blood cells
(B) Fasting glucose and insulin
(C) Cholesterol and triglycerides
(D) Urea, uric acid, and creatinine

91. A Pap smear (Papanicolaou test) is a regular preventative screening procedure used to detect potentially pre-cancerous and cancerous processes in the:
(A) Colon
(B) Ovaries
(C) Uterus lining
(D) Cervix

92. For a normal healthy adult, the standard range for a Fasting Blood Sugar (FBS) test is generally considered to be:
(A) 70 to 100 mg/dL
(B) 110 to 140 mg/dL
(C) 150 to 180 mg/dL
(D) 40 to 60 mg/dL

93. A disease that continuously exists within a specific geographic region or population at a baseline level is referred to as:
(A) Epidemic
(B) Endemic
(C) Pandemic
(D) Sporadic

94. The public health practice of separating and restricting the movement of individuals who have been exposed to a contagious disease to see if they become sick is called:
(A) Isolation
(B) Quarantine
(C) Vaccination
(D) Disinfection

95. Match the insect vectors in List I with the diseases they primarily transmit in List II, relevant to public health control measures.
List I: Insect Vectors
P. Aedes aegypti
Q. Female Anopheles
R. Culex mosquito
S. Sandfly
List II: Diseases
1. Malaria
2. Dengue
3. Kala-azar (Leishmaniasis)
4. Filariasis (Elephantiasis)
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-1, R-2, S-3

96. Under public health initiatives, campaigns such as "Nirogi Rajasthan" primarily focus on:

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(C) Boiling water vigorously before consumption
(D) Using Reverse Osmosis (RO) systems where heavy metals are present

120. Which is the most appropriate approach for building a healthy society?
(A) Focusing exclusively on constructing specialized quaternary tertiary care referral hospitals
(B) Relying completely on government intervention to cure diseases after symptoms develop
(C) Completely avoiding routine medical check-ups in favor of untested alternative remedies
(D) Combining personal hygiene, civic responsibility, and public health participation

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108. The childhood viral disease Measles is caused by a virus belonging to the family:
(A) Paramyxoviridae
(B) Retroviridae
(C) Flaviviridae
(D) Orthomyxoviridae

109. Severe protein deficiency in infants and children, characterized by edema, a swollen belly, and poor growth, is clinically known as:
(A) Marasmus
(B) Kwashiorkor
(C) Scurvy
(D) Pellagra

110. The Poliovirus, which causes poliomyelitis in children, is primarily transmitted through which route?
(A) Vector-borne transmission via infected mosquito bite
(B) Ingestion via the fecal-oral transmission route
(C) Inhalation of airborne respiratory droplets
(D) Parenteral exposure through direct blood contact

111. Rickets is a childhood disease that leads to the softening and weakening of bones due to a prolonged deficiency of:
(A) Vitamin D and Calcium
(B) Fat-soluble Vitamin A
(C) Water-soluble Vitamin C
(D) Dietary mineral Iron

112. In emergency medical assistance, what does the life-saving acronym CPR stand for?
(A) Cardiac Pressure Response
(B) Central Pulmonary Revival
(C) Cardiopulmonary Resuscitation
(D) Cardiovascular Pulse Regulation

113. In trauma and emergency medicine, the critical period immediately following a traumatic injury when prompt medical care has the highest likelihood of preventing death is known as the:
(A) Recovery window
(B) Silver minute
(C) Vital period
(D) Golden hour

114. The recommended first-aid protocol for a minor superficial thermal burn is to immediately:
(A) Immediately apply household butter or cooking oil directly over the burn site
(B) Carefully pierce any formed blisters to release accumulated fluid early
(C) Continuously flush affected skin with cool running water for 10-15 minutes
(D) Directly apply dry ice blocks onto the skin to freeze the affected area

115. A tourniquet should be applied in an emergency medical situation ONLY when:
(A) Superficial localized bleeding occurs from a minor abrasion or scrape on a limb
(B) Severe arterial limb hemorrhage occurs, uncontrolled by direct pressure
(C) An individual sustains an acute envenomation injury from a venomous snakebite
(D) Significant localized tissue swelling and edema develops due to a bone fracture

116. Proper handwashing with soap and water is an individual responsibility that is most effective in preventing the transmission of:
(A) Inherited systemic genetic disorders
(B) Chronic life-threatening cardiovascular diseases
(C) Severe long-term nutritional deficiencies
(D) Gastrointestinal and respiratory infections

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117. In the context of bio-medical waste management to prevent public health hazards, contaminated plastic items like syringes and IV sets are disposed of in bins of which color?
(A) Red
(B) Yellow
(C) Blue
(D) White (translucent)

118. Consider the following two statements regarding personal and community hygiene:
Statement I: Personal hygiene involves practices like bathing and brushing teeth to maintain one's own health.
Statement II: Community hygiene involves proper disposal of waste and maintaining clean public surroundings to prevent epidemics.
(A) Statement I is true, Statement II is false
(B) Statement I is false, Statement II is true
(C) Both Statement I and Statement II are true
(D) Both Statement I and Statement II are false

119. All of the following are safe practices to ensure the availability of potable (drinking) water to prevent diseases, EXCEPT:
(A) Storing drinking water in open, uncovered containers
(B) Chlorination of municipal water supplies

10. (C) Polyuria
Polyuria refers to the excessive or abnormally frequent excretion of urine. In diabetic conditions, elevated blood glucose levels exceed the renal threshold for reabsorption. Consequently, unabsorbed glucose remains in the renal tubules, exerting an osmotic gradient that draws water into urine, thereby inducing osmotic diuresis and frequent fluid voiding behaviors in patients.

11. (C) Assertion (A) is true but Reason (R) is false.
Patients with severe diabetes excrete glucose in urine, a condition known as glycosuria. This occurs because blood glucose concentrations exceed the renal threshold, preventing complete reabsorption by the nephrons. The reasoning is incorrect because glucose appears in urine during hyperglycemia, when blood glucose levels are abnormally high rather than low.

12. (A) Insulin
Insulin is a peptide hormone secreted by the beta cells of the pancreas in response to elevated blood glucose levels. It lowers plasma glucose by facilitating cellular uptake in skeletal muscle and adipose tissue via GLUT4 transporters. Additionally, it promotes glycogenesis in the liver and inhibits gluconeogenesis to maintain metabolic balance.

13. (B) 120/80 mmHg
Arterial blood pressure is expressed as a fraction consisting of systolic and diastolic pressures measured in millimeters of mercury. In a healthy resting adult, standard blood pressure is approximately 120/80 mmHg. The upper value represents ventricular contraction pressure, whereas the lower value reflects arterial resistance during cardiac relaxation between heartbeats.

14. (B) Regular aerobic exercise
Primary hypertension develops progressively without a single identifiable secondary medical cause. Major risk factors include high dietary sodium intake, chronic psychological stress, clinical obesity, excessive alcohol consumption, and physical inactivity. Engaging regularly in aerobic exercise actually lowers systemic vascular resistance, improves endothelial function, and helps maintain healthy blood pressure levels.

15. (A) Sphygmomanometer
A sphygmomanometer is a specialized medical instrument designed to measure arterial blood pressure. It typically consists of an inflatable rubber cuff, a pressure gauge or mercury column, and a mechanism for inflation. When combined with a stethoscope to detect Korotkoff sounds, it accurately records both systolic and diastolic arterial pressures.

16. (C) Right Atrium → Right Ventricle → Lungs → Left Atrium → Left Ventricle
Deoxygenated blood from systemic circulation enters the right atrium through the vena cava and passes into the right ventricle. The right ventricle pumps this blood to the lungs via pulmonary arteries for oxygenation. Oxygenated blood returns through pulmonary veins into the left atrium and flows to the left ventricle for systemic distribution.

17. (D) Atherosclerosis
Atherosclerosis is a progressive vascular disease characterized by the accumulation of lipids, cholesterol, cellular debris, and calcium within the intima of arterial walls. This forms atherosclerotic plaques that restrict vascular lumen diameter, reduce arterial elasticity, impair localized tissue perfusion, and significantly increase the risk of myocardial infarction and ischemic stroke.

18. (C) Heart attack
A myocardial infarction, commonly referred to as a heart attack, occurs when blood flow to a portion of the myocardium is severely reduced or completely obstructed. This ischemia typically results from acute thrombus formation following atherosclerotic plaque rupture in a coronary artery, causing irreversible necrosis of cardiac muscle tissue cells.

19. (B) P-3, Q-1, R-2, S-4
An electrocardiogram traces electrical activity generated during the cardiac cycle. The P wave corresponds to atrial depolarization preceding atrial contraction. The QRS complex represents rapid ventricular depolarization. The T wave signifies ventricular repolarization as ventricles relax. A flat baseline indicates an electrical resting state with no measurable membrane potential changes.

20. (D) High-Density Lipoprotein (HDL)
High-Density Lipoprotein is termed good cholesterol because it transports excess cholesterol from peripheral tissues back to the

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liver for excretion or catabolism, a process known as reverse cholesterol transport. Higher circulating levels of high-density lipoproteins reduce arterial cholesterol deposition, thereby protecting blood vessels against atherosclerosis and coronary artery vascular disease.

21. (A) Metastasis
Metastasis is the complex biological process in which malignant cancer cells detach from a primary tumor site, invade surrounding tissues, and migrate via blood vessels or lymphatic channels to colonize distant organs. This invasive capability distinguishes malignant neoplasms from benign tumors and represents a primary challenge in effective clinical cancer management.

22. (C) Oncogenes
Oncogenes are mutated or overexpressed forms of normal cellular genes called proto-oncogenes, which regulate cell growth, division, and differentiation. When point mutations, gene amplifications, or chromosomal translocations alter proto-oncogenes into oncogenes, they induce gain-of-function effects, promoting unregulated cellular proliferation, inhibiting physiological cell death, and driving clinical cancer tumorigenesis.

23. (A) Carcinomas arise from the epithelial cells lining body surfaces.
Carcinomas represent the most prevalent class of human cancers, originating from epithelial tissues that line internal organs, skin, and mucosal surfaces. Conversely, sarcomas arise from mesenchymal tissues like muscle and bone. Leukemias are hematologic malignancies derived from blood-forming bone marrow tissues, whereas lymphomas develop primarily within lymphatic system structural components.

24. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Benign tumors consist of localized masses of abnormal cells that grow slowly and remain enclosed within a fibrous capsule. Because they lack the capacity to invade adjacent normal tissues or metastasize through vascular channels to distant organs, benign tumors are considered non-cancerous and significantly less dangerous than invasive malignant neoplasms.

25. (B) Inflammation and constriction of lower respiratory airways
Asthma is a chronic inflammatory disorder of the lower respiratory tract, primarily affecting the bronchi and bronchioles. Hyper-responsiveness to various environmental triggers induces smooth muscle bronchospasm, mucosal edema, and hypersecretion of thick mucus. These pathological alterations narrow airway lumens, leading to symptoms like dyspnea, coughing, chest tightness, and characteristic wheezing sounds.

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26. (C) Bronchi
Bronchitis is a respiratory condition characterized by inflammation of the mucous membranes lining the bronchial tubes, which carry air into the lungs. This inflammatory reaction triggers hypersecretion of mucus, excessive coughing, and airway narrowing. It can present either as an acute viral infection or as a chronic progressive inflammatory disease.

27. (D) Emphysema
Emphysema is a chronic obstructive pulmonary disease characterized by permanent destruction of interalveolar septa, leading to enlarged, flaccid air spaces. Long-term exposure to cigarette smoke triggers enzymatic degradation of elastin by elastases. This structural loss diminishes alveolar elastic recoil and drastically reduces total surface area available for pulmonary gas exchange.

28. (A) I and II only
Asthma involves bronchial inflammation that restricts airflow and causes characteristic wheezing. Prolonged occupational inhalation of silica dust leads to silicosis, which produces severe pulmonary tissue fibrosis. Emphysema causes irreversible breakdown of alveolar walls, which significantly reduces the respiratory surface area for gas exchange instead of expanding it, impairing oxygen diffusion.

29. (B) Liver
Jaundice is a clinical sign characterized by yellowish discoloration of the skin, mucous membranes, and sclera due to hyperbilirubinemia. Bilirubin is a byproduct of hemoglobin breakdown processed by hepatic parenchymal cells. Liver dysfunction, biliary tract obstruction, or excessive hemolysis impairs bilirubin conjugation and excretion, accumulating pigment in systemic bodily tissues.

30. (B) Helicobacter pylori
Peptic ulcer disease involves mucosal erosions in the stomach or duodenum that extend into the muscularis mucosae. Helicobacter pylori, a gram-negative flagellated bacterium, colonizes the gastric mucosa by producing urease, neutralizing acid, and triggering chronic mucosal inflammation. This bacterial activity weakens protective mucus barriers, allowing gastric acid to erode mucosal layers.

31. (A) P-3, Q-4, R-1, S-2
Digestive system diseases exhibit distinct clinical features and etiologies. Cholera is a bacterial infection producing profuse rice-water diarrhea. Typhoid fever is confirmed clinically through the Widal serological test. Constipation involves infrequent bowel movements with prolonged fecal retention in the colon. Diarrhea causes abnormal bowel movement frequency and increased fecal liquidity.

32. (C) ORS
Oral Rehydration Salts, abbreviated as ORS, consist of a balanced aqueous solution of glucose and essential electrolytes including sodium, potassium, chloride, and citrate. Administering ORS utilizes active glucose-coupled sodium transport mechanisms across the intestinal epithelium, significantly accelerating fluid absorption and effectively managing dehydration caused by acute severe diarrheal illnesses.

33. (D) Passive osmosis and diffusion
Hemodialysis is a medical procedure used during renal failure to clear metabolic waste products from blood. Blood flows through a semipermeable membrane surrounded by dialysate fluid. Waste molecules like urea and creatinine move down concentration gradients via passive diffusion, while excess body fluid is removed through ultrafiltration driven by osmotic and hydrostatic pressure differentials.

34. (C) Uremia
Uremia is a severe clinical syndrome resulting from severe renal failure, characterized by toxic accumulation of urea, nitrogenous waste products, and metabolic toxins in blood. Impaired glomerular filtration prevents proper excretion, causing metabolic acidosis, electrolyte imbalances, pericarditis, encephalopathy, and systemic complications unless treated with dialysis or successful kidney transplantation.

35. (B) Calcium oxalate
Renal calculi, commonly known as kidney stones, are solid mineral deposits formed within the renal calyces and pelvis. The majority of urinary tract stones are composed of crystallized calcium oxalate. Super-saturation of urine with calcium and oxalate ions promotes crystal nucleation, aggregation, and retention, which can cause urinary obstruction and renal colic.

36. (C) Both Statement I and Statement II are true
Antidiuretic hormone, released by the posterior pituitary, acts on renal collecting ducts to insert aquaporin channels, promoting water reabsorption into circulation. A deficiency in antidiuretic hormone synthesis or action causes diabetes insipidus. This condition prevents effective renal water retention, resulting in excretion of copious dilute urine and severe unquenchable thirst.

37. (A) Treponema pallidum
Syphilis is a complex sexually transmitted bacterial infection caused by the spirochete Treponema pallidum. The organism gains entry through intact mucous membranes or microscopic skin abrasions during sexual contact. Left untreated, the disease progresses through primary, secondary, latent, and tertiary stages, potentially causing systemic, cardiovascular, and neurological complications over time.

38. (C) Genital herpes
Genital herpes is a viral sexually transmitted infection predominantly caused by Herpes Simplex Virus Type 2. The virus establishes lifelong latent infection in sensory nerve ganglia, periodically reactivating to produce painful mucosal blisters. Although antiviral medications suppress viral replication and manage symptomatic outbreaks, there is currently no cure to eradicate latent herpes virus.

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39. (A) P-3, Q-4, R-2, S-1
Sexually transmitted diseases are caused by diverse microbiological pathogens. Gonorrhea is a bacterial infection caused by Neisseria gonorrhoeae. Trichomoniasis is triggered by the flagellated protozoan parasite Trichomonas vaginalis. Genital warts result from human papillomavirus, a DNA virus. Acquired Immunodeficiency Syndrome is caused by the Human Immunodeficiency Virus, a complex human retrovirus.

59. (D) Mukhyamantri Chiranjeevi Swasthya Bima Yojana
The Mukhyamantri Chiranjeevi Swasthya Bima Yojana is a flagship health insurance scheme initiated by the Government of Rajasthan. It provides comprehensive financial protection by offering cashless inpatient medical treatment in empanelled public and private hospitals, protecting families from catastrophic healthcare expenditures caused by severe acute and chronic medical illnesses.

60. (A) A CHC acts as a referral unit for several PHCs and has specialist doctors.
In India's rural healthcare architecture, Primary Health Centres serve as first-contact facilities providing basic preventive and curative services for populations around 20,000 to 30,000. Community Health Centres function as secondary referral units covering 80,000 to 120,000 people, equipped with 30 beds, surgical facilities, and resident specialist medical doctors.

61. (B) Schizophrenia
Schizophrenia is a severe chronic psychiatric disorder characterized by structural breakdown in thought processes, impaired emotional responsiveness, and altered perception of reality. Prominent positive symptoms include auditory or visual hallucinations and fixed false delusions, while negative symptoms manifest as flattened affect, avolition, and social withdrawal, causing profound personal functional impairment.

62. (B) Clinical Depression
Clinical depression, or major depressive disorder, is a common mental health condition marked by persistent low mood, loss of interest or pleasure in activities, fatigue, and diminished energy levels. Pathological features include altered sleep patterns, appetite fluctuations, feelings of worthlessness, impaired concentration, and significant ongoing cognitive impairment.

63. (A) Serotonin
Serotonin, chemically known as 5-hydroxytryptamine, is a monoamine neurotransmitter produced in serotonergic neurons within the raphe nuclei. It regulates mood, emotion, sleep, appetite, and cognitive functions. Decreased synaptic serotonin levels are strongly implicated in the pathogenesis of depressive disorders, which is why selective serotonin reuptake inhibitors serve as effective antidepressants.

64. (C) P-4, Q-2, R-1, S-3
Specific psychological phobias and sleep disorders exhibit distinct diagnostic parameters. Acrophobia is an intense irrational fear of heights. Insomnia involves chronic difficulty falling or staying asleep. Anorexia nervosa is an eating disorder characterized by extreme restriction of food intake and severe weight loss. Claustrophobia is an irrational fear of enclosed spaces.

65. (D) Cortisol
Cortisol is a glucocorticoid steroid hormone synthesized and secreted by the zona fasciculata of the adrenal cortex. Stimulated by adrenocorticotropic hormone during chronic physiological or psychological stress, cortisol mobilizes glucose via gluconeogenesis, elevates arterial blood pressure, alters lipid metabolism, and suppresses immune activity to maintain metabolic balance under sustained stress.

66. (C) Sympathetic nervous system
Acute threat exposure triggers the flight or fight response through sympathetic nervous system activation. Preganglionic sympathetic fibers stimulate the adrenal medulla to release catecholamines, epinephrine and norepinephrine, into circulation. This physiological shift increases heart rate, dilates respiratory bronchioles, redirects blood flow to skeletal muscles, and elevates vigilance to prepare for action.

67. (B) Suppressing the immune system
Chronic activation of the hypothalamic-pituitary-adrenal axis results in sustained secretion of cortisol. Prolonged high cortisol concentrations suppress systemic immune function by inhibiting lymphocyte proliferation, reducing pro-inflammatory cytokine production, and downregulating antibody responses. Consequently, chronic psychological stress increases host vulnerability to opportunistic infections, delayed wound healing, and systemic inflammatory disorders.

68. (A) I and II only
Mindfulness meditation and deep breathing stimulate parasympathetic tone while dampening sympathetic hyperactivity, thereby lowering heart rate and blood pressure. Regular physical

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densities of Anopheles, Culex, and Aedes mosquitoes, thereby mitigating the transmission of vector-borne diseases.

50. (C) Louis Pasteur
Pasteurization was discovered by the French microbiologist Louis Pasteur during the mid-nineteenth century. This thermal preservation technique involves heating liquids like milk to controlled temperatures below boiling point for a specified duration, killing heat-sensitive pathogenic bacteria without curdling milk proteins. This discovery drastically reduced foodborne disease transmission human populations globally.

51. (B) Routine administration of a Hepatitis B vaccine
Primary prevention interventions aim to prevent the onset of disease before biological pathology occurs by addressing underlying risk factors and enhancing host immunity. Administering vaccines, such as the Hepatitis B vaccine, creates specific protective immunity prior to pathogen exposure, effectively protecting healthy individuals and reducing overall disease incidence across populations.

52. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Thermal processing by bringing water to a sustained boil at 100°C serves as an accessible method to sanitize drinking water. Elevated temperatures denature essential structural proteins, disrupt plasma membranes, and permanently bioinactivate heat-sensitive pathogenic microorganisms, including pathogenic bacteria, protozoa, and viruses, thereby preventing waterborne infectious disease transmission globally.

53. (A) Naturally acquired passive immunity
Naturally acquired passive immunity occurs when preformed protective antibodies are transferred directly from mother to offspring through natural biological pathways. Maternal immunoglobulins, predominantly IgA present in colostrum and breast milk, confer immediate temporary immunological protection to the infant's gastrointestinal mucosa without requiring the neonate's own immune system to generate an active response.

54. (C) Tuberculosis disease
The Bacillus Calmette-Guérin vaccine is a live attenuated vaccine prepared from Mycobacterium bovis strains. Administered primarily to neonates and young children, BCG provides targeted protection against tuberculosis caused by Mycobacterium tuberculosis. It significantly reduces the risk of severe extrapulmonary manifestations in pediatric populations, including tuberculous meningitis and disseminated miliary tuberculosis.

55. (A) P-2, Q-4, R-1, S-3
Essential childhood immunizations protect against targeted infectious pathogens. The DPT vaccine immunizes against diphtheria, pertussis, and tetanus. Oral Polio Vaccine provides mucosal and systemic immunity against poliovirus strains. The MMR vaccine protects against measles, mumps, and rubella viruses. Tetanus Toxoid supplies focused active immunity against Clostridium tetani neurotoxin production effects.

56. (D) 2 - 3 - 4 - 1
The adaptive immune response follows a sequential pathway. Pathogen entry into tissues initiates foreign antigen exposure. Professional antigen-presenting cells like macrophages engulf the invader via phagocytosis and process its antigens. These processed antigens are presented to T-helper cells, which activate antigen-specific B-lymphocytes to differentiate and produce neutralizing protective antibodies.

57. (B) Alma-Ata Declaration
The Alma-Ata Declaration was adopted in 1978 during the International Conference on Primary Health Care in Kazakh Soviet Socialist Republic. Organized by the World Health Organization and UNICEF, this landmark declaration established primary healthcare as the fundamental key to attaining the core global goal of "Health for All" worldwide.

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58. (C) Accredited Social Health Activist
ASHA stands for Accredited Social Health Activist, a trained female community health worker recruited under India's National Health Mission. Positioned at the village level, ASHA workers bridge rural communities and the public health system, promoting maternal health, childhood immunization, sanitation awareness, and facilitating healthcare access in underserved rural population areas.

40. (D) Sharing of injection needles does not transmit STDs under any circumstances.
Sharing contaminated injection needles is a major route of blood-borne disease transmission, including sexually transmitted viruses such as HIV, Hepatitis B, and Hepatitis C. Effective prevention of sexually transmitted diseases relies on practicing safe sex using barrier methods, limiting sexual partners, maintaining proper hygiene, and avoiding needle sharing or contaminated medical equipment.

41. (B) CD4+ T-helper cells
The Human Immunodeficiency Virus selectively infects and destroys CD4+ T-helper lymphocytes, which are essential coordinators of the adaptive immune system. Viral glycoprotein gp120 binds to the CD4 receptor and co-receptors on T-cells. As CD4+ cell counts progressively decline, cell-mediated immunity becomes severely compromised, leaving the body vulnerable to opportunistic infections.

42. (C) ELISA test
The Enzyme-Linked Immunosorbent Assay, commonly known as ELISA, is a highly sensitive serological laboratory technique used as the primary screening tool for HIV infection. It detects specific anti-HIV antibodies produced by the host immune system in response to viral antigens. Reactive ELISA results are subsequently confirmed using highly specific Western blot or nucleic acid tests.

43. (D) 2 - 4 - 1 - 3
The replication cycle of Human Immunodeficiency Virus begins with viral attachment and entry into CD4+ host cells. Reverse transcriptase then synthesizes viral DNA from single-stranded viral RNA. Integrase incorporates this viral DNA into host chromosomal DNA. Finally, viral proteins and genome assemble at the plasma membrane to release new infectious virions.

44. (A) Sharing food and utensils with an infected person
Human Immunodeficiency Virus is transmitted through specific body fluids, including blood, semen, vaginal secretions, and breast milk. Transmission occurs via unprotected sexual intercourse, contaminated blood transfusions, needle sharing, or mother-to-child transmission during pregnancy, delivery, or lactation. Casual contact such as sharing food, utensils, or hugging does not transmit the virus.

45. (B) Magnetic Resonance Imaging
Magnetic Resonance Imaging, abbreviated as MRI, is a non-invasive medical imaging modality that uses powerful magnetic fields, radio waves, and computer algorithms to generate detailed cross-sectional images of internal soft tissues, organs, and bones. Unlike X-rays and CT scans, MRI does not utilize ionizing radiation, providing excellent soft tissue contrast.

46. (B) Acute typhoid fever
The Widal test is a serological diagnostic procedure used to detect enteric fever caused by Salmonella enterica serotype Typhi. The agglutination reaction identifies specific antibodies, namely somatic O and flagellar H agglutinins, in patient serum against bacterial antigens. Significant rising antibody titers confirm active acute typhoid fever patient clinical diagnosis.

47. (A) I and II only
Biopsy involves removing tissue samples for microscopic pathological examination to detect malignancies. Endoscopes are illuminated optical tubular instruments inserted into anatomical cavities to visually inspect internal hollow organs. Ultrasound imaging utilizes non-ionizing high-frequency sound waves rather than ionizing X-rays to visualize internal tissues, ensuring safe clinical diagnostic evaluation.

48. (C) Brain
An Electroencephalogram, abbreviated as EEG, is a non-invasive neurodiagnostic test that records spontaneous electrical activity generated by cerebral cortical neurons. Electrodes attached to the scalp detect voltage fluctuations resulting from ionic current flows within brain tissue, assisting clinicians in diagnosing neurological disorders such as epilepsy, sleep disturbances, and systemic encephalopathy.

49. (D) Direct mosquito larvae control to prevent malaria spread
Introducing Gambusia affinis, commonly known as mosquitofish, into freshwater bodies is a biological vector control strategy. These larvicidal fish actively feed on aquatic mosquito larvae and pupae before adult emergence. Reducing larval populations effectively suppresses vector

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exercise enhances endorphin release and reduces circulating stress hormones like cortisol and adrenaline. High caffeine consumption acts as a central nervous system stimulant, escalating anxiety and elevating stress responses.

69. (A) Central nervous system and gastrointestinal tract
Opioids are analgesics that exert physiological effects by selectively binding to specific G-protein-coupled opioid receptors, including mu, kappa, and delta subtypes. These receptors are densely distributed throughout the central nervous system, where they modulate pain perception, and the gastrointestinal tract, where they inhibit peristaltic motility and prolong intestinal transit time.

70. (C) Diacetylmorphine
Heroin, commonly known as smack, is a semi-synthetic opioid drug derived chemically from morphine via acetylation using acetic anhydride. Its chemical name is diacetylmorphine. Diacetylmorphine crosses the blood-brain barrier rapidly due to high lipid solubility, where it is metabolized into morphine, producing intense euphoria, analgesia, respiratory depression, and high addiction risk.

71. (A) Dopamine
Cocaine is a potent central nervous system stimulant alkaloid derived from Erythroxylum coca leaves. It acts primarily by binding to and blocking the presynaptic dopamine transporter mechanism. This inhibition prevents dopamine reuptake into presynaptic terminals, causing accumulation of dopamine in synaptic clefts of the brain reward pathway, triggering euphoria and addiction.

72. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A.
Repeated administration of addictive substances downregulates receptor sensitivity and density within central neuronal circuits. As receptor responsiveness declines, neuroadaptation occurs, requiring progressively higher drug doses to achieve the initial physiological or euphoric effect. This receptor tolerance drives compulsive escalating drug consumption, reinforcing chemical dependence and physical addiction over extended time.

73. (B) Nicotine
Nicotine is an alkaloid compound found in tobacco leaves. Upon inhalation or absorption, nicotine binds selectively to nicotinic acetylcholine receptors in the brain and peripheral autonomic ganglia. This binding stimulates the adrenal medulla to release epinephrine and norepinephrine into circulation, elevating blood pressure, accelerating heart rate, and mediating chemical addiction.

74. (C) Reduces the oxygen-carrying capacity of hemoglobin
Inhaling tobacco smoke introduces carbon monoxide into lungs, where it rapidly diffuses across alveoli into systemic blood. Carbon monoxide binds to hemoglobin with an affinity approximately 200 times greater than oxygen, forming carboxyhemoglobin. This competitive displacement reduces systemic oxygen transport and impairs tissue oxygen delivery throughout the entire human body.

75. (D) Oral cavity cancer
Chewing smokeless tobacco exposes mucosal membranes of the mouth directly to carcinogenic chemical compounds, including tobacco-specific nitrosamines and polycyclic aromatic hydrocarbons. Prolonged contact triggers cellular dysplasia, leukoplakia, and genetic mutations in oral epithelial cells, leading to a significantly heightened incidence of oral cavity carcinomas and severe oral periodontal diseases.

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76. (A) Nostrils → Pharynx → Larynx → Trachea → Bronchi → Alveoli
During inhalation, atmospheric air enters the nostrils, passing through nasal cavities for filtration, warming, and humidification. It flows sequentially through the pharynx, larynx past the vocal cords, and down the trachea. The trachea bifurcates into primary bronchi, branching into smaller bronchioles that terminate in alveolar sacs for pulmonary gas exchange.

77. (B) Liver Cirrhosis
Prolonged heavy alcohol consumption induces chronic hepatic injury through oxidative stress and acetaldehyde toxicity. The liver progresses from fatty liver, or steatosis, to alcoholic hepatitis, and ultimately to liver cirrhosis. Cirrhosis is characterized by irreversible replacement of healthy hepatic parenchyma with fibrous scar

tissue, compromising hepatic blood flow and metabolic function.

78. (A) Ethanol
Ethanol, or ethyl alcohol, is the principal psychoactive compound found in commercial alcoholic beverages. It acts as a central nervous system depressant by enhancing inhibitory neurotransmission mediated by gamma-aminobutyric acid receptors and suppressing excitatory N-methyl-D-aspartate glutamate receptors, leading to sedation, impaired motor coordination, cognitive slowdown, and neurological behavioral changes.

79. (A) Fetal Alcohol Syndrome (FAS)
Maternal ingestion of alcohol during pregnancy allows ethanol to cross the placental barrier easily, reaching the developing fetus. Because the fetal liver lacks sufficient metabolic enzymes, ethanol causes cellular disruption and teratogenic damage, producing Fetal Alcohol Syndrome. FAS is characterized by craniofacial abnormalities, growth restriction, structural brain malformations, and permanent neurodevelopmental deficits.

80. (C) P-2, Q-4, R-1, S-3
Psychoactive substances affect brain function through distinct pharmacologic actions. Alcohol acts primarily as a central nervous system depressant. Caffeine is a widely consumed central nervous system stimulant. Lysergic acid diethylamide is a potent hallucinogen altering sensory perception. Marijuana contains active cannabinoids like tetrahydrocannabinol, acting on endocannabinoid physiological neural receptors.

81. (D) Lactic acid
During intense physical exercise, cellular oxygen demand exceeds vascular oxygen delivery, forcing skeletal muscles into anaerobic glycolysis. Pyruvate generated from glucose breakdown cannot enter mitochondrial aerobic pathways and is converted by lactate dehydrogenase into lactic acid. Dissociated lactate and hydrogen ions accumulate in muscle tissue, lowering intracellular pH and inducing muscular fatigue.

82. (C) Weight in kg / (Height in meters)^2
Body Mass Index is a standardized anthropometric parameter used to categorize human body mass and evaluate adult health risks. It is calculated by dividing total body weight in kilograms by the square of body height in meters. The resulting numerical value provides a general population measure for screening undernutrition, normal weight, overweight, and obesity.

83. (B) 18.5 to 24.9
World Health Organization guidelines define adult Body Mass Index classification ranges for clinical assessment. A BMI value between 18.5 and 24.9 kg/m^2 falls within the normal or healthy weight category. Values under 18.5 indicate underweight status, ranges from 25.0 to 29.9 denote overweight, and scores of 30.0 or above reflect clinical obesity.

84. (D) It improves insulin sensitivity, reducing the risk of Type 2 diabetes.
A sedentary lifestyle involves prolonged physical inactivity and low energy expenditure. This pattern impairs skeletal muscle glucose uptake, promotes ectopic lipid storage, downregulates insulin receptor signaling, and causes systemic insulin resistance, escalating the risk of Type 2 diabetes. Regular physical exercise, rather than physical inactivity, is required to enhance tissue insulin sensitivity.

85. (A) Vitamin C
Vitamin C, or ascorbic acid, is an essential water-soluble micronutrient that acts as an antioxidant and enzymatic cofactor. It is critical for collagen hydroxylation, enabling connective tissue synthesis, wound healing, and vascular integrity. Furthermore, ascorbic acid enhances non-heme iron absorption in the gut and boosts innate and adaptive immune cell functions.

86. (C) Leukocytes
Leukocytes, or white blood cells, serve as primary cellular defenders within the human immune system. Divided into granulocytes, such as neutrophils, eosinophils, and basophils, and agranulocytes, such as lymphocytes and monocytes, leukocytes identify, engulf, and neutralize invading pathogens, produce specific antibodies, and coordinate cellular immune defense mechanisms throughout body tissues.

87. (A) I and II only
Vitamin D modulates innate and adaptive immune responses by regulating antimicrobial peptide production in immune cells. Zinc is indispensable for leukocyte differentiation, signal transduction,

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and cytokine production. Iron deficiency impairs immunocompetence by depressing T-lymphocyte proliferation and phagocytic activity rather than causing an overactive immune response, making the third premise incorrect.

88. (D) Thymus
The thymus is a primary lymphoid organ situated in the superior anterior mediastinum behind the sternum, directly overlying the pericardium. Immature T-cell progenitor cells migrate from bone marrow into the thymus, where they undergo gene rearrangement, positive selection for self-MHC recognition, and negative selection against self-reactivity to form functional T-lymphocytes.

89. (B) Breast cancer
Mammography is a specialized radiographic screening procedure that uses low-energy X-ray beams to image breast tissue microarchitecture. It enables early detection of non-palpable malignant lesions, microcalcifications, and structural tissue asymmetry before clinical symptoms emerge, significantly improving prognosis and lowering breast cancer mortality through timely early medical intervention.

90. (C) Cholesterol and triglycerides
A lipid profile is a comprehensive panel of clinical blood tests measuring serum concentration of specific circulating lipids and lipoproteins. The panel quantitatively measures total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, very low-density lipoprotein, and triglycerides. These measurements assist clinicians in evaluating cardiovascular health and atherosclerotic disease risk.

91. (D) Cervix
The Pap smear, or Papanicolaou test, is a routine gynecological screening procedure designed to detect precancerous cellular changes and carcinoma of the uterine cervix. Exfoliated cervical epithelial cells collected from the ectocervix and endocervical canal are examined microscopically for dysplasia caused by persistent high-risk human papillomavirus viral infections.

92. (A) 70 to 100 mg/dL
Fasting blood sugar testing measures plasma glucose concentrations following an overnight fast of at least eight hours. For healthy non-diabetic adults, normal fasting plasma glucose ranges between 70 and 100 mg/dL. Fasting levels from 100 to 125 mg/dL indicate impaired fasting glucose or prediabetes, whereas levels exceeding 126 mg/dL signify diabetes.

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93. (B) Endemic
An endemic disease is an infectious condition or pathogen that maintains a constant baseline presence and predictable prevalence within a specific geographic location or population group without external input. In contrast, epidemics represent sudden spikes in disease incidence above expectations, while pandemics signify global disease outbreaks extending across multiple continents.

94. (B) Quarantine
Quarantine is a public health strategy restricting movement and social contact of asymptomatic individuals who have been exposed to a contagious infectious agent. This measure monitors whether individuals develop clinical disease during the incubation period. Isolation differs by specifically separating confirmed symptomatic infected individuals from healthy populations to prevent transmission.

95. (A) P-2, Q-1, R-4, S-3
Arthropod vectors transmit distinct pathogenic organisms to human hosts. Aedes aegypti mosquitoes transmit viral infections including dengue, chikungunya, and zika. Female Anopheles mosquitoes transmit Plasmodium protozoa, causing malaria. Culex mosquitoes spread filarial worms responsible for lymphatic filariasis. Sandflies act as primary vectors transmitting Leishmania protozoa, causing kala-azar disease.

96. (C) Preventive healthcare, lifestyle modification, and public health awareness
The Nirogi Rajasthan campaign is a health awareness initiative aimed at promoting preventive health measures and encouraging healthy lifestyle practices. The program focuses on reducing non-communicable disease risks, raising public awareness regarding environmental hygiene, maternal and child welfare, drug addiction control, and encouraging regular health screenings to improve population health outcomes.

97. (D) Malaria, Dengue, and Chikungunya
The National Vector Borne Disease Control Programme is a umbrella public health program in India responsible for preventing and controlling vector-borne illnesses. Targeted diseases include malaria, dengue, chikungunya, Japanese encephalitis, lymphatic filariasis, and kala-azar. Control strategies emphasize vector surveillance, larval habitat control, indoor residual spraying, and prompt early disease treatment.

98. (C) CoWIN
CoWIN, short for COVID Vaccine Intelligence Network, is a cloud-based digital portal launched by the Government of India. It managed the national COVID-19 vaccination drive by facilitating user registration, appointment scheduling, dose tracking, and generating verifiable digital vaccination certificates, serving as a critical digital infrastructure for large-scale public health administration.

99. (B) WHO
The World Health Organization, established on April 7, 1948, is the specialized agency of the United Nations responsible for international public health. Headquartered in Geneva, Switzerland, WHO sets global health standards, coordinates disease control efforts, leads international epidemic responses, promotes health research, and assists member states in achieving universal health coverage.

100. (D) 7th April
World Health Day is observed annually on 7th April to mark the anniversary of the founding of the World Health Organization in 1948. Each year, the organization selects a specific global health theme to highlight priority public health issues, raising awareness and mobilizing international action on critical physical and mental health challenges.

101. (A) HIV/AIDS
The Red Ribbon is a globally recognized symbol created in 1991 to raise awareness, express solidarity, and demonstrate support for people living with HIV/AIDS. It represents compassion for those affected, encourages education about viral transmission, counteracts social stigma, and promotes international efforts focused on HIV prevention, research, and treatment access.

102. (C) To enable individuals to adopt healthy choices and make informed lifestyle decisions
Health education aims to empower individuals and communities by imparting knowledge, developing skills, and fostering health literacy. It encourages people to adopt positive health behaviors, make informed lifestyle choices, prevent disease, and reduce risk factors. Through clear communication, health education transforms public understanding into personal responsibility for sustained health and wellness.

103. (A) Mass media rapidly disseminates key information during epidemic outbreaks.
Mass media platforms, including television, radio, print, and digital channels, serve as critical tools in public health communication. During disease outbreaks, mass media rapidly disseminates accurate preventative information, containment guidelines, and emergency advisories to broad populations, counteracting misinformation and enabling swift public response during regional public health emergencies.

104. (D) Osteoporosis
Osteoporosis is a progressive skeletal disorder characterized by reduced bone mineral density, loss of bone microarchitecture, and increased bone fragility. Aging, hormonal decline, particularly postmenopausal estrogen deficiency, and insufficient calcium or vitamin D intake accelerate bone resorption over bone formation, significantly increasing fracture risk in susceptible older adult individuals.

105. (B) Nervous system (Brain)
Alzheimer's disease is a neurodegenerative disorder causing progressive cortical atrophy and cognitive decline in elderly individuals. Extracellular deposition of amyloid-beta plaques and intracellular neurofibrillary tangles composed of hyperphosphorylated tau proteins cause synaptic destruction and neuronal loss, particularly within the hippocampus and cerebral cortex, severely impairing memory and human cognition.

106. (C) Presbyopia
Presbyopia is an age-related refractive error caused by progressive loss of elasticity in the crystalline ocular lens and weakening of the surrounding ciliary muscle fibers. This structural alteration diminishes the eye's accommodative amplitude, making it difficult to focus on close

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objects, commonly requiring convex reading lenses for near vision correction.

107. (D) Progressive clouding and opacity of the natural crystalline lens
Cataract is a prevalent ocular condition in aging populations involving progressive opacification and clouding of the natural crystalline lens. Denaturation and aggregation of lens crystallin proteins block light transmission to the retina, causing painless blurred vision, reduced contrast sensitivity, glare intolerance, and eventually complete vision impairment unless successfully surgically treated.

108. (A) Paramyxoviridae
Measles is a highly contagious childhood viral infection caused by the Measles virus, an enveloped, single-stranded negative-sense RNA virus belonging to the genus Morbillivirus within the Paramyxoviridae family. Transmitted via airborne respiratory droplets, measles causes fever, cough, coryza, conjunctivitis, Koplik spots, and a characteristic maculopapular spreading skin rash.

109. (B) Kwashiorkor
Kwashiorkor is a form of severe acute malnutrition resulting from severe protein deficiency despite adequate caloric intake. Decreased plasma protein concentration lowers intravascular oncotic pressure, leading to peripheral fluid accumulation and generalized edema, abdominal distension, fatty liver change, depigmented hair, skin lesions, and muscle wasting in vulnerable young children.

110. (B) Ingestion via the fecal-oral transmission route
Poliovirus is an enterovirus transmitted primarily through the fecal-oral route via ingestion of food or water contaminated with infected human feces. The virus multiplies within gastrointestinal epithelial cells and local lymphoid tissues, shedding in stool. In a subset of cases, poliovirus invades the central nervous system, selectively destroying motor neurons.

111. (A) Vitamin D and Calcium
Rickets is a pediatric bone disorder resulting from prolonged deficiency of vitamin D, calcium, or phosphate. Vitamin D deficiency impairs intestinal calcium absorption, leading to hypocalcemia and secondary hyperparathyroidism. This prevents proper mineralization of developing osteoid tissue at epiphyseal growth plates, producing soft, weak, delayed skeletal development and bowed leg deformities.

112. (C) Cardiopulmonary Resuscitation
Cardiopulmonary Resuscitation, abbreviated as CPR, is an emergency life-saving procedure performed when an individual experiences sudden cardiac arrest or respiratory arrest. It combines repetitive chest compressions to maintain manual blood circulation to vital organs with artificial ventilation to oxygenate blood, sustaining vital organ function until advanced life support measures can be initiated.

113. (D) Golden hour
The golden hour refers to the critical initial hour immediately following traumatic physical injury or acute emergency medical events. Rapid assessment, stabilization, and definitive medical treatment delivered within this window significantly minimize tissue hypoxia, prevent irreversible organ damage, limit systemic shock progression, and optimize survival rates for critically injured emergency patients.

114. (C) Continuously flush affected skin with cool running water for 10-15 minutes
Immediate first-aid for minor thermal burns requires flushing the affected dermal area with cool running tap water for ten to fifteen minutes. This rapid cooling dissipates trapped heat energy, stops progressive thermal tissue destruction, reduces local mucosal inflammation, and relieves pain. Applying butter, ice, or popping blisters is contraindicated due to infection risks.

115. (B) Severe arterial limb hemorrhage occurs, uncontrolled by direct pressure
A tourniquet is a tight constricting band applied around a limb proximal to a wound to stop severe arterial hemorrhage. Because tourniquets completely occlude arterial blood flow and cause downstream tissue ischemia, their application is restricted to life-threatening extremity bleeding that cannot be controlled by direct physical wound pressure.

116. (D) Gastrointestinal and respiratory infections
Proper hand hygiene using soap and water mechanically removes, inactivates, and rinses away pathogenic bacteria, viruses, and parasites acquired from contaminated surfaces. Regular

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handwashing interrupts transmission pathways, drastically reducing the spread of infectious pathogens responsible for gastrointestinal conditions like diarrhea and acute respiratory infections like influenza across diverse human populations.

117. (A) Red
Under standardized bio-medical waste management rules, color-coded bins facilitate safe segregation, handling, and disposal of medical waste. Red-colored bins are specifically designated for recyclable contaminated plastic waste, including disposable syringes without needles, intravenous tubing sets, catheters, and urine bags, which undergo autoclaving or microwaving prior to industrial plastic recycling.

118. (C) Both Statement I and Statement II are true
Personal hygiene encompasses individual habits such as bathing, handwashing, and oral care that safeguard individual body health. Community hygiene involves collective environmental efforts, including safe sewage disposal, proper solid waste management, and maintaining clean public surroundings. Both levels of hygiene operate synergistically to minimize pathogen transmission and prevent infectious disease epidemics.

119. (A) Storing drinking water in open, uncovered containers
Storing drinking water in open, uncovered containers exposes it to insect vectors, dust, airborne pathogens, and domestic contamination, making it unsafe for human consumption. Safe potable water practices require covering storage vessels, municipal water chlorination, vigorous boiling to eliminate microbes, and applying reverse osmosis filtration to remove dissolved toxic contaminants.

120. (D) Combining personal hygiene, civic responsibility, and public health participation
Building a healthy society requires an integrated holistic strategy combining personal hygiene habits, civic environmental responsibility, active community participation, and accessible public health infrastructure. Relying solely on curative clinical interventions or government action is insufficient, whereas promoting disease prevention, health literacy, and collective civic participation ensures sustainable long-term population health.

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